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AMMUNITION

INSTRUCTIONS FOR THE NAVAL SERVICE

1923

G. D. Erskine

N. Ord. 6.

IN REPLY ADDRESS
BUREAU OF ORDNANCE, NAVY DEPARTMENT
AND REFER TO No.

NAVY DEPARTMENT
BUREAU OF ORDNANCE
WASHINGTON, D. C.

40416
(F6)O
MJC/ECL

15 August 1924

CIRCULAR LETTER NO. X-131

To: All Bureaus, Ships and Stations.

Subject; Addendum to Bureau of Ordnance Pamphlet No. 4.

1. It is requested that the following page be added to Bureau of Ordnance Pamphlet No. 4;

Page 159(1)

6 (a) In order that firing circuits on destroyers and other vessels having case guns and director or master-key fire, may be tested, the Bureau has modified cartridge cases to take lock primers which are readily reloadable. The 4"/50 case is shown on Bureau drawing #116972 and is called dummy cartridge Mark III. All 4"/50 caliber gun destroyers with director fire are supplied with four Mark III cartridge cases and 218 lock drill primers, in accordance with revised allowance lists.

6(b) In no case will projectiles be supplied for these cartridge cases or used with them.

6(c) The Bureau will arrange to issue similar type cartridge cases for 5"/25 and 3"/50 caliber guns when equipped with director or master-key fire.

6(d) Requisitions or letter requests are not necessary to obtain this material, and additional equipment will be supplied in accordance with the allowance lists as manufactured.

C. C. Bloch

C. C. Bloch
Chief of Bureau.

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Ordnance Pamphlet No. 4
September, 1923

DEPARTMENT OF THE NAVY BUREAU OF ORDNANCE

AMMUNITION

INSTRUCTIONS FOR THE NAVAL SERVICE

1923

This publication is FOR OFFICIAL USE ONLY and will be handled in accordance with Art. 123, U. S. Naval Regulations, 1920.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1924

N. Ord. 6.

IN REPLY ADDRESS
BUREAU OF ORDNANCE, NAVY DEPARTMENT
AND REFER TO No.

40416
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ECL

NAVY DEPARTMENT
BUREAU OF ORDNANCE
WASHINGTON, D. C.

15 May 1924

CIRCULAR LETTER NO. X-110

To: All Ships in Commission
All ammunition depots; Naval Districts; Navy Yards; Naval Ordnance Plants; Naval Training Stations; Naval War College; Naval Missions to Brazil and Peru; Naval Operations (Materiel) Bureaus Aeronautics, Construction and Repair, Engineering, Supplies and Accounts, Yards and Docks; Inspectors of Ordnance, Engineering and Hull Material; Marine Corps Headquarters; Coast Guard Headquarters; Naval Academy (Including Postgraduate School); Powder Factories; Proving Grounds; Receiving stations; Submarine Bases; Torpedo Stations and Schools; Army Ordnance

Subject: Ordnance Pamphlet No. 4 - Ammunition Instructions for the Naval Service - 1923 - distribution.

Enclosure: (A) Ordnance Pamphlet No. 4

1. The Bureau is forwarding this date Ordnance Pamphlet No. 4, "Instructions Governing the Care, Preservation, Stowage, Inspection, and Test of Ammunition".

2. Attention is invited to Page III of this publication, and particularly to that portion which lists Ordnance Pamphlets superseded by Ordnance Pamphlet No. 4. These publications - Ordnance Pamphlets Nos. 20, 21, and 368 Part II - will not be declared obsolete until the stock on hand is exhausted, and they will continue to be carried in the Index to Ordnance Pamphlets. However, when the stock on hand becomes exhausted they will not be reprinted.

C. C. Bloch
C.C.Bloch
Chief of Bureau.

INSTRUCTIONS GOVERNING THE CARE, PRESERVATION, STOWAGE, INSPECTION, AND TEST OF AMMUNITION.

1. Ordnance Pamphlet No. 4, published in accordance with article 74 of the Navy Regulations, 1920, covers instructions governing the care, preservation, stowage, inspection, and test of service explosives and general information about ammunitions. No attempt has been made to go deeply into the general subject of ammunition materials, as the subject is too broad for general consumption. Officers seeking more detailed information should consult standard works on explosives, consulting the list compiled under the direction of the National Council of Research. For more complete information regarding dispersion, erosion, and interior ballistics, consult ordnance pamphlets on these subjects. This publication supersedes Ordnance Pamphlets Nos. 20, "Service Explosives"; 368, Part II, "Marking of Ammunition"; 21, "Pyrotechnic Signal Material," and all previous instructions regarding tests of service explosives. Practically all of the subject matter of chapter 26, Naval Instructions, 1913, is incorporated in this book, and in accordance with article 74 (*b*), of the Navy Regulations, 1920, still have the force and effect of orders from the Navy Department. This publication should be given a free circulation for the proper dissemination of information, so that due regard will be paid to the care, preservation, and tests of ammunition.

2. Shipment of explosives by freight or express must be packed and marked in accordance with the Interstate Commerce Commission Regulations for the Safe Transportation of Explosives, copies of which are on file at the various navy yards and stations, including naval ammunition depots. When it becomes necessary for a vessel to ship ammunition by freight or express, it is preferable to turn it in to an ammunition depot for proper packing, loading, and placarding, if such turning in is practicable, otherwise to the supply officer of a navy yard or station. Shipment of explosives by mail is positively FORBIDDEN.

Attention is invited to the following works on explosives:

Nitro Explosives	Sanford.
The Manufacture of Explosives	Guttman.
Explosives	Marshall.
High Explosives	Calver.
Explosives	Brunswig.

GENERAL INDEX.

Page.

Table of contents........ vii

CHAPTER I. General instructions........ 1

II. Safety precautions........ 9

III. Definitions and history of explosives........ 19

IV. Black powder........ 25

V. Smokeless powder........ 29

VI. Tests of smokeless powder........ 61

VII. Surveillance ovens........ 75

VIII. High explosives........ 95

IX. Detonating substances........ 107

X. Projectiles........ 111

XI. Cartridge cases and tanks........ 157

XII. Fuses and tracers........ 171

XIII. Primers........ 195

XIV. Assembled charges........ 199

XV. Miscellaneous ammunition........ 205

XVI. Aircraft ammunition........ 221

XVII. Storage of ammunition........ 225

XVIII. Marking of ammunition........ 233

XIX. Pyrotechnics........ 245

XX. Interior ballistics........ 251

XXI. Erosion........ 269

XXII. Dispersion........ 273

XXIII. Reports........ 279

List of illustrations........ xv

TABLE OF CONTENTS.

Subject.	Page.	Illustrations.	
		Figure.	Plate.

Chapter I.

General Instructions.

Subject.	Page.	Figure.	Plate.
Sources of information	1		
Bureau publications	1		
Handling of explosives	1		
Ammunitions	2		
Damage to containers	2		
Charges	3		
Danger of leaky containers	3		
Handling projectiles and empty containers	4		
Smokeless powder	4		
Temperatures	4		
Exposure of smokeless powder to sun or high temperatures	5		
Wet powder	5		
Safety devices	5		
Service ammunition	5		
Inspection of target ammunition	6		
Disposition of unexpended allowance	6		
Use of proper containers	6		
Drill primers	6		
Small arms	7		
Material	7		
Service projectiles	7		

Chapter II.

Safety Precautions.

Subject.	Page.	Figure.	Plate.
Extent of precautions	9		
Forbidden articles	9		
Red flag	9		
Safety orders	9		
General	9		
Magazine	10		
Ammunition	10		
Preparations for firing	10		
Steaming out oil tanks	16		
Use of magazines	16		
Ready service magazines	16		
Unloading guns	16		
Deflective primers	17		
Immersing powder in water	17		

TABLE OF CONTENTS—Continued.

Chapter III.

Definitions and History of Explosives.

Subject.	Page.	Illustrations.	
		Figure.	Plate.
Explosion and explosive	19		
Conditions for an explosion	19		
Explosive reaction	19		
Explosive mixture and compound	20		
Heat of explosion	20		
Sensitivity	20		
Classification of explosives	21		
Propellant and high explosive	21		
Requirements of an explosive	21		
Early history, Greek fire	22		
First use and development of black powder	22		
Nitro compounds	23		
Guncotton	23		
Nitroglycerin	23		
Other nitro compounds	23		
Substitutes for black powder	23		
Early smokeless powder	24		
Nitrocellulose and nitroglycerine powders	24		
Adoption of new propellants	24		
Further developments	24		

Chapter IV.

Black Powder.

Composition	25		
Saltpeter	25		
Sulphur	25		
Charcoal	26		
Manufacture of black powder	26		
Physical properties	28		
Packing	28		
Uses	28		

Chapter V.

Smokeless Powder.

Cellulose	29		
Cotton	29		
Cellulose nitrates, soluble, insoluble	29		
Nitration	30		
Other nitrocellulose substances	30		
Tinters and hull shavings, purification	30		
Cotton fiber structure	31		
Sulphuric acid	31		
Nitric acid	32		
Manufacture of nitrocellulose	34		
Mixed acids	38		

TABLE OF CONTENTS—Continued.

Chapter V—Continued.

Smokeless Powder—Continued.

Subject.	Page.	Illustrations.	
		Figure.	Plate.
Pyro purification, drowning, boiling, pulping, beaters, poaching, dewatering, dehydrating, mixing	39		
Dephenylamine	44		
Pressing	44		
Powder dies	49	21	
Solvent recovery	49		
Drying	49		
Blending	50		
Burning of black and smokeless powder	50		
Quick and slow powders	54		
Shape of grains	55		
Double base powders	55		
Stabilizers	57		
Reworked powder	57		
Smokeless powder manufacture test	58		
Special propellants	59		
Flashless powder	59		

Chapter VI.

Examination of Tests of Powder Aboard Ship.

Subject.	Page.	Figure.	Plate.
Assignment to lots	61		
Designation of lots	61		
Stability	62		
Care in carrying out tests	62		
Record of tests	63		
Prescribed tests	63		
Magazine samples	63		
Daily examination	64		
Principles of violet paper tests	64		
Fortnightly tests	66		
Monthly tests	66		
Visual examination	67		
Surveillance test	67		
Results from tests	68		
Reports	69		
Danger point	69		
Surveillance test bottles	69		
Method of conducting tests	70		
Transportation	70		
Regulation for explosives	71		
Destruction of powder	72		
Ballistic error of powder	73		
Salvage of ammunition	73		

TABLE OF CONTENTS—Continued.

Subject.	Page.	Illustrations.	
		Figure.	Plate.

Chapter VII.

Surveillance Ovens.

Subject.	Page.	Figure.	Plate.
Source of supply	75		
Purpose	75		
Mark I, and Mark I, Mod. 1, ovens	75		
To connect ovens	83		
Panel	84		
To test thermometers	85		
Operation of ovens	85		
Mark II oven	86		
Operation of Mark II oven	90		
The Mark II, Mod. 2, oven	92		
Alarm device	92		
Ovens in service	94		

Chapter VIII.

High Explosives.

Subject.	Page.	Figure.	Plate.
Requirements	95		
List of high explosives	96		
Guncotton	97		
T. N. T.	98		
T. N. X.	101		
Picric acid	102		
Ammonium picrate	103		
Manufacture of explosive "D"	103		
Tetryl	104		
Amatol	104		
Nitrostarch	105		
Nitroglycerine	105		

Chapter IX.

Detonating Substances.

Subject.	Page.	Figure.	Plate.
General	107		
Ignition of smokeless powder	107		
Projectile fillers	107		
Detonation	108		
Boosters	109		
Fulminate of mercury	109		
Caps for small arms	110		
Azides	110		

Chapter X.

Projectiles.

Subject.	Page.	Figure.	Plate.
General	111		
Form of	111		
Exterior finish, weight	112		
Bourrelet	113		

TABLE OF CONTENTS—Continued.

Chapter X—Continued.

Projectiles—Continued.

Subject.	Page.	Illustrations.	
		Figure.	Plate.
Rotating band	113		
Under water attack	114		
Classification	115		
Manufacture of armor-piercing projectiles	115		
Common and class "B" projectiles	118		
Special projectiles	120		
Illuminating projectiles	120		
Smoke and gas projectiles	121		
Target projectiles	121		
Proof shot projectiles	121		
Marker projectiles	121		
Line-carrying projectiles	121		
Tabulation of characteristics	122		

Chapter XI.

Cartridge Cases and Case Ammunition.

Cartridge cases	157		
Manufacture of cases	157		
Care of cases	158		
List of cartridge cases	159		
Care in handling case ammunition	159		
Cartridge tanks and boxes	160		
Powder tanks	165		

Chapter XII.

Fuses and Tracers.

Nomenclature	171		
List of fuses	171		
Early history	174		
Concussion fuse	175		
Percussion fuse	175		
Navy base fuse	177		
Broderick fuse	177		
Driggs fuse	177		
Wilson Chase fuse	178		
Simple minor caliber fuse	178		
Ansonia & Nathan fuse	179		
Baldwin fuse	179		
Watson medium caliber fuse	179		
Simple medium caliber fuse	180		
Tracers	180		
Time fuses	180		
Fuse setters, punch, and wrench	188		

TABLE OF CONTENTS—Continued.

Subject.	Page.	Illustrations.	
		Figure.	Plate.

Chapter XIII.

Primers.

Function of primer 195
Ignition 195
Types of primers 195
Manufacture 196
Designation 196
Drill primers 196

Chapter XIV.

Assembled Charges.

Issue to vessels 199
Ammunition orders 199
Handling orders 199
Loading projectiles 201
Mixed filler 201
Compressed charges 201
Case ammunition 201
Bag charges 202
Ignition ends 202
Assembly of bags 203
Stacked charges 204

Chapter XV.

Miscellaneous Ammunition.

Types of small arms 205
Issue of small arms ammunition 205
Care in handling 208
Classes and grades 208
Marking of small arms 209
Shotgun ammunition 209
Torpedo impulse charges 209
Y-gun charges 210
Instruction for preparation of saluting ammunition 210
Stokes mortar ammunition 212
Variable propellant charges 212
Precautions 212
Rifle grenades 212
Hand grenades 216
Line throwing ammunition 219

Chapter XVI.

Aircraft Ammunition.

Aero bombs 221
Fragmentation bombs 221
Demolition bombs 221
Incendiary bombs 222
Antisubmarine bomb 222

TABLE OF CONTENTS—Continued.

Chapter XVI—Continued.

Aircraft Ammunition—Continued.

Subject.	Page.	Illustrations.	
		Figure.	Plate.
Armor-piercing bomb	222		
Smoke bomb	222		
Gas bomb	222		
Dummy bomb	222		
Care and handling of aero bombs	223		
Marking and painting of bombs	224		
Machine-gun ammunition	224		
Pyrotechnics	224		
Torpedoes	224		

Chapter XVII.

Stowage of Ammunition.

Subject.	Page.	Figure.	Plate.
Stowage regulations	225		
Ready service stowage	228		
Location of magazines	228		
Safety precautions	228		
Care of magazines	228		
Wet powder	229		
Temperatures	229		
Moisture	229		
Refrigeration	229		
Necessity for cooling	230		
Reliability of cooling system	230		
Cost	231		

Chapter XVIII.

Marking of Ammunition.

Subject.	Page.	Figure.	Plate.
General instructions	233		

Chapter XIX.

Pyrotechnics.

Subject.	Page.	Figure.	Plate.
Pyrotechny	245		
Materials used	245		
Kinds of pyrotechnics	245		
Rockets	245		
Navy rockets	246		
Star rockets	247		
Signal rockets	247		
Shower rockets	247		
Identification marks	247		
Smoke rockets	247		
Very signals	248		
Very stars	248		
Packing of stars	249		
Rifle light and discharger	249		
Blue light	249		
Distress signal	250		
Handling pyrotechnics	250		

TABLE OF CONTENTS—Continued.

Chapter XX.

Interior Ballistics.

Subject.	Page.	Illustrations.	
		Figure.	Plate.
Use of	251		
Extent of	251		
Gun requirements	251		
Powder	252		
Powder chamber	252		
Density of loading	252		
Travel of projectile	253		
Use of formulas	253		
Development of interior ballistics	253		
Application of formulas	254		
Formulæ used	254		
Problems	255		
Powder test sheet	255		

Chapter XXI.

Erosion.

Subject.	Page.	Figure.	Plate.
Cause	269		
Appearance of steel in bore	269		
Heat cracks and their effect	269		
Elements affecting erosion	270		
Heat of combustion	270		

Chapter XXII.

Dispersion.

Subject.	Page.	Figure.	Plate.
Causes	273		
Errors in dispersion	273		
Speed of primers	277		
Variation in projectiles	278		

Chapter XXIII.

Ammunition Reports.

Subject.	Page.	Figure.	Plate.
Importance	279		
Number of reports	279		
Circular Letter No. A-27 of February 17, 1921	281		
Sample reports	285		

Chapter XXIV.

Special Tests of Ammunition.

Subject.	Page.	Figure.	Plate.
Guncotton	303		
Guncotton boosters	303		
Drying	304		
Stowage	305		
Weekly inspection	306		

TABLE OF CONTENTS—Continued.

Chapter XXIV—Continued.

Special Tests of Ammunition—Continued.

Subject.	Page.	Illustrations. Figure.	Illustrations. Plate.
Litmus list of guncotton	306		
Monthly inspection	307		
Quarterly inspection	307		
Annual inspection	307		
Heat tests	308		
Heat tests outfit	308		
Operation of heat test for smokeless powder	309		
Heat test for guncotton	310		
Delicacy of heat test	311		
Litmus test of guncotton	311		

Illustrations.

Chapter V.

Subject.	Page.	Figure.	Plate.
Sulphur burner	32	1	
Nitric-acid still	33	2	
Cotton-picking machine	34	3	
Cotton drier	35	4	
Diagrammatic sketch of nitrating process	37		I
Cotton nitrators (third floor)	36	5	
Nitrating house (second floor)	38	6	
Pyro discharge of boiling tubs (first floor)	39	7	
Boiling tubs	40	8	
Duplex heater, pulping machine	41	9	
Poaching tubs	42	10	
Pyro screens	43	11	
Dewatering and wringing machines	43	12	
Dehydrating press	45	13	
Mixing machine	46	14	
Blocking presses	46	15	
Macaroni press	47	16	
Graining press	47	17	
Grain cutter (cover in place)	47	18	
Grain cutter (cover removed)	48	19	
Sorting tables	48	20	
Powder die for multiperforated grains	49	21	
Solvent recovery	50	22	
Typical interior of dry house	51	23	
Blending tower	52	24	
Packing room	53	25	
Graphic progress of combustion of multiperforated grain	53		II
Combustion pressure curves	54	26	
Reworking mill	57	27	

Chapter VII.

Subject.	Page.	Figure.	Plate.
Mark I oven, assembled view	78	28	III
Mark I oven, disassembled view	79	29	IV
General arrangement, Mark I, Mod. 1, oven	76		III
Mark I, Mark I, Mod. 1, wiring diagram	77		IV

TABLE OF CONTENTS—Continued.

Illustrations—Continued.

Chapter VII—Continued.

Subject.	Page.	Illustrations. Figure.	Illustrations. Plate.
Mark II oven showing rheostat	86	30	
Mark II oven showing relay	87	31	
Mark II oven interior	88	32	
Mark II, Mod. 1, oven	90		V
Mark II, Mod. 1, wiring diagram	Appended.		LIV
Mark II, Mod. 2, oven	90		VI
Mark II, Mod. 2, wiring diagram	Appended.		LV
Mark II, Mod. 1, heating unit	91		VII

Chapter XI.

Subject.	Page.	Illustrations. Figure.	Illustrations. Plate.
Operations for 4-inch, 50-caliber cartridge case	158	33	
Assembly, 1-pounder, ammunition	160		VIII
Assembly, 3-pounder, ammunition	160		IX
Assembly, 6-pounder, ammunition	160		X
Assembly, 3″/23 field gun ammunition	160		XI
Assembly, 3″/23 low velocity ammunition	160		XII
Assembly, Davis gun ammunition, 6-pounder, 9-pounder, and 3-inch	160		XIII
Assembly, 3″/50 ammunition	160		XIV
Assembly, 4″/50 ammunition	160		XV
1-pounder ammunition boxes, Mark II and Mark III	161	34	
3″/23 cartridge tank, Mark I	161	35	
3″/23 ammunition boxes, Mark IV and IV, Mod. 1	162	36	
3″/50 ammunition boxes, Mark I, Mod. 1	162	37	
3″/50 ammunition tank, Mark II, with extractor	163	38	
4″/40 ammunition box; also used for 3″/50 illuminating projectile	163	39	
4″/50 cartridge tank, Mark II	164	40	
4″/50 cartridge boxes, Mark III and Mark III, Mod. 1	164	41	
6″/40 ammunition box, Mark II	165	42	
Miscellaneous packing boxes for primers and detonators, one copper and one sheet metal	166	43	
5-inch powder tanks	169	44	
12-inch powder tanks	169	45	
14-inch powder tanks	170	46	
16-inch powder tanks with opener and slings	170	47	

Chapter XII.

Subject.	Page.	Illustrations. Figure.	Illustrations. Plate.
Navy base fuse (53260)	177	48	
Broderick fuse (53163)	177	49	
Driggs fuse (14464)	178	50	
Wilson-Chase fuse (26527)	178	51	
Semple minor caliber fuse (54917)	179	52	
Watson medium caliber fuse (50210)	179	53	
Semple medium caliber ignition fuse	180	54	
Bethlehem 12-second combination time and percussion fuse (53164)	182	55	
Frankford Arsenal 15-second combination time and percussion fuse (17698)	184	56	
Frankford Arsenal 21-second combination fuse, 1907 (46848)	185	57	
Detonating fuse, Mark VII (51757)	187	58	
15-second F. A. C. fuse punch and a 21-second F. A. C. fuse wrench	189	59	
3 hand-fuse setters	191	60	
Outline of different tracers	194		XVI

TABLE OF CONTENTS—Continued.

Illustrations—Continued.

Chapter XIII.

Subject.	Page.	Illustrations. Figure.	Illustrations. Plate.
Mark X, Mod. 4, and Mark XIV primers	197	......	XVII
Mark XV lock primer and the Mark XIII case combination ignition primer	Appended	......	LVI
Outline of primers	198	......	XVIII

Chapter XIV.

Subject.	Page.	Illustrations. Figure.	Illustrations. Plate.
Stacking machines, Naval Ammunition Depot, St. Juliens Creek	200	......	XVIX
Loose and stacked section for 14-inch charge	203	61	....

Chapter XV.

Subject.	Page.	Illustrations. Figure.	Illustrations. Plate.
Containers for small-arm ammunition aircraft and machine gun	206	......	XX
Containers for small-arm ammunition machine gun rifle	207	......	XXI
Torpedo impulse ammunition	210	......	XXII
Y-gun ammunition	210	......	XXIII
Stokes trench mortar projectile	213	......	XXIV
Cross section O. B. rifle grenade	214	62	....
Hand grenade	216	63	....
3 and 6 pounder line-throwing projectiles	218	64	....

Chapter XVIII.

Subject.	Page.	Illustrations. Figure.	Illustrations. Plate.
Powder containers	233	......	XXV
Explosive containers	235	......	XXVI
Bag gun charge containers	236	......	XXVII
Projectiles loaded and fused	238	......	XXVIII
Projectile data	239	......	XXIX
Separate case ammunition box	240	......	XXX
Fixed case ammunition box	241	......	XXXI
Fixed case ammunition box	241	......	XXXII
Fixed case ammunition box	241	......	XXXIII
Fixed case ammunition box	241	......	XXXIV
Fixed case ammunition box	241	......	XXXV
Fixed case ammunition box	241	......	XXXVI
Cartridge tank	241	......	XXXVII
Saluting ammunition box	242	......	XXXVIII
Replacement sample	242	......	XXXIX
Drill case ammunition box	243	......	XL
Drill charge ammunition containers	244	......	XLI
Aircraft bombs	244	......	XLII

Chapter XIX.

Subject.	Page.	Illustrations. Figure.	Illustrations. Plate.
Star rockets	247	......	XLIII
Shower rockets	247	......	XLIV
Smoke rockets	247	......	XLV
Very signal pistol	247	......	XLVI
Very cartridges, assembled and sectional, showing distinguishing features	247	......	XLVII
Rifle lights, assembled and sectional, showing distinguishing features	247	......	XLVIII
Blue and red lights, assembled and sectional, showing distinguishing features	247	......	XLIX

TABLE OF CONTENTS—Continued.

Subject.	Page.	Illustrations.	
		Figures.	Plate.
Illustrations—Continued.			
Chapter XX.			
Gun design curves	258	....	L
Velocity curves	264	....	LI
Curves for M. V. 2,700 foot-seconds for 5-inch, 50-caliber gun	265	....	LII
Variation of the several elements in a 12-inch, 54-caliber gun with changes of density of loading	267	....	LIII

SEPTEMBER, 1923.

AMMUNITION.

INSTRUCTION FOR THE NAVAL SERVICE.

Chapter I.

GENERAL INSTRUCTIONS.

Instructions for ashore and afloat.

1. The instructions contained in this Ordnance Pamphlet, promulgated primarily for the service afloat, shall be followed at all naval ammunition depots, naval mine depots, and other stations on shore, in so far as they are applicable.

Instructions for ordnance material.

2. The methods of caring for and handling ordnance material as set forth in—

(*a*) United States Navy Regulations and Instructions, and
(*b*) Ordnance pamphlets

shall be closely followed.

Detailed instructions.

3. Detailed instructions relative to any particular class of ordnance will be found in the following publications:

(*a*) Ordnance pamphlets.
(*b*) Gunnery Instructions.
(*c*) Ship and Gun Drills.
(*d*) Landing Force Manual.
(*e*) Diving Manual.
(*f*) Navy General Orders, dealing with that particular subject.

When in doubt as to the meaning of any regulation or instruction concerning ordnance, an interpretation should be requested from the Bureau of Ordnance.

File of ordnance publications.

4. Commanding officers shall have on file a complete and up-to-date set of ordnance publications covering all ordnance material and ammunition on board the vessels under their command. Ordnance pamphlets may be obtained from the Bureau of Ordnance upon request, obtaining the pamphlet number from the index published as Pamphlet No. 0.

Handling of explosives.

5. The exercise of the utmost care and prudence in handling, inspecting, testing, preparing, assembling, and transporting all kinds of ammunition and ammunition details is enjoined upon all officers and other persons whose duties require cognizance over or actual handling of explosives during any of the above operations. Subordinates are liable to become careless and indifferent when continually engaged in work with explosives and, as long as nothing occurs, are inclined to drift gradually into a neglect of necessary precautions. Nothing but constant vigilance on the part of officers and others in charge will insure the constant observance by subordinates of the rules and regulations which experience has taught to be necessary. Safety precautions, rules and regulations for handling explosives should be made the subject for frequent instruction, and the necessity for strict compliance therewith should be so firmly fixed on new men that they will invariably and subconsciously do the proper thing thereafter. Attention should be especially invited to the fact that in the earlier stages of the use of explosives the experience gained has been at a costly price. No relaxation of any regulation should be tolerated, as this tends to induce an idea that the rules are arbitrary.

Use of signs.

6. The use of placards and signs containing admonitory notices, serving as a constant reminder of the safety precautions, are sometimes condemned as having the effect of creating a fear of explosives, especially in new men. The use of signs is probably not so vitally required aboard ship as in shore plants, but their obvious advantages should not be overlooked.

Handling of ammunition.

7. Handling of ammunition shall be reduced to the minimum in order to prevent the occurrence of leaky containers, damaged tanks and cartridge cases, loosened projectiles, torn cartridge bags, etc., in order to reduce the chances of accidents. The number of men allowed in the vicinity of explosives should, as far as practicable, depending on the requirements of the operation, be reduced to the minimum for properly performing the work in hand. It frequently happens that unnecessarily large working parties are assembled for handling live ammunition. Every effort and known precaution is taken to make ammunition safe in handling under all conditions, but this should not presuppose that an accident may not happen, and, therefore, unnecessarily subjecting the personnel to the effects of such is unwarranted.

Damage to containers.

8. Of equal importance to be considered in the handling of ammunition is the question of damage to containers. A study of smokeless powder shows how exposing it to the air affects its stability in a very injurious manner. Powder tanks are so constructed that they will remain air-tight as long as the gaskets hold, hence, if care is observed in handling not to dent the body so as to open the seams, or to loosen the top rings or covers, and on periodic inspections to note that the gaskets are holding up, one may be assured that the powder is properly protected from the atmosphere. In handling powder tanks, dents are frequently caused by the use of cargo nets, by rolling them along decks and over obstructions, by allowing the bodies or rings to strike projections when hoisting or lowering, or by dropping them. When powder tanks are opened for inspection, the gaskets and general air-tight condition of the tank shall be observed. It is impossible to give a standard method of handling tanks, but, in general, they shall be hoisted and lowered with care, carried along decks by hand or transported by truck.

Danger in damaged containers.

9. An armored cruiser turned in her service allowance of ammunition to a depot for overhaul. While it was aboard the ship, the reports of surveillance tests ashore gave 50 days and on board ship about 60 days, showing that apparently the powder was entirely satisfactory for continued use afloat for a number of years. During the overhaul, a number of leaky tanks were discovered and the tests on powder taken from them gave less than *six days surveillance test.* The real danger to the safety of this ship and crew is apparent, but may be more fully realized when it is considered that the action of a deteriorating powder is progressive—that is, the presence of nitrous oxide fumes react to cause more molecules to breakdown. Carelessness on the part of the personnel resulted in the condition of these tanks. Many instances are on file in the Bureau of Ordnance where sister ships have turned in their service allowances for overhaul, one requiring practically no repairs and the other requiring most extensive repairs and loss of material. The investigation into the poor condition of one ship's outfit disclosed the fact that the powder tanks had been transferred from ship to lighter by dumping them down a chute. The only explanation for such utter disregard of existing instruction can be found in the failure of the personnel to appreciate the significance of their carelessness.

Damage to charges.

10. Aside from the danger of leaky powder tanks, there are other serious conditions which arise. The silk cartridge bag cloth is attacked by the nitrous fumes and would soon impair the serviceability of the charges for loading. The rotting bag would burst, scattering powder grains with the resulting danger and delay. Powder in leaky containers will not only give different results from that predetermined on proof, but will give erratic results, to the serious inconvenience of fire control. The seriousness of permitting ammunition to deteriorate so that it would not only be ineffective but dangerous and erratic in battle should appear to every person who participates in the teamwork which produces the correct answer in battle, namely, "hits per gun per minute." Smokless powder in leaky containers shall be landed at the earliest practicable moment after discovery, for replacement, unless a surveillance test shows it to be in normal condition, and the container can be repaired.

Handling projectiles.

11. The greatest care shall be exercised in handling loaded and fused projectiles. A projectile which has been dropped from a height exceeding 5 feet shall be set aside and turned in to an ammunition depot. Such a projectile shall be clearly marked to show its condition and shall be handled with the greatest care. Upon receipt at a naval ammunition depot it shall be unfused and the fuse scrapped. Fuses are designed and manufactured so that a fused projectile may be dropped without causing the fuse to function, but additional drops or the shock of firing may cause a fuse action. The new type nonfringing rotating bands which are being furnished to the service are very easily damaged. Careless handling will be ruinous to these bands. The ammunition depots are continually reporting projectiles received from ships with damaged rotating bands.

Empty containers.

12. Empty cartridge cases, boxes, and powder tanks shall be handled and stored with care and shall be turned in to a naval ammunition depot at the earliest opportunity. To prevent deformation, cartridge cases, still hot from firing, should not be laid on their sides or roughly handled. Before stowing empty cartridge cases below, they shall be freed from all inflammable gases. This can best be done by inserting a lighted taper in each case as far as the bottom, thus setting fire to any inflammable gas, or by washing out the cases. As soon as practicable, they shall be thoroughly washed out with hot water and soap, dried, and repacked in the boxes or tanks in which they were supplied.

Powder charges.

13. Navy smokeless powder is manufactured to contain, in the finished grain, a standard percentage of "residual volatiles," which is as low as practical considerations will permit. Under normal conditions of storage, the volatiles will not become appreciably reduced. Futhermore, powder is packed at the factory, and charges are made up at the naval ammunition depots, under normal atmospheric conditions as far as practicable to obtain a standard percentage of surface moisture. The charges for bag guns are issued in air-tight tanks and charges for case guns are virtually sealed by cork composition devices or by the projectiles. The weights of charge are established by actually firing samples of the various indices under standard condition of volatiles, temperatures, etc., and it is most important, for ballistic reasons, that the powder undergoes no change in service thereafter. To insure this, those charged with its care shall see that the air-tightness of the containers is rigidly maintained. Powder exposed to the atmosphere will lose a portion of its residual volatiles, and on board ship will gain or lose surface moisture. While the changes may be counteractive, it is unlikely that they will exactly offset each other, therefore, the importance of keeping powder charges air-tight is to be considered on a par with that, for instance, of keeping the sights in condition.

Temperature of charges.

14. The "proof" of powder, besides being held under normal conditions as regards volatiles and moisture, is conducted with the powder at a temperature of 90° F. Variations in storage temperatures do not affect the regularity of the powder. Loss of stability, unless it has gone so far as to preclude retaining the powder on board ship, will not of itself affect ballistics if the other conditions are normal.

Exposure to sun.

15. When smokeless powder is removed from magazines at naval ammunition depots or on board ship for transportation, gunnery exercises, or other purposes, it shall not be exposed to the direct rays of the sun or subjected to other abnormal conditions of temperature. This prohibition applies equally to powder in bulk, in tanks, cartridge cases, ammunition boxes, or other containers. Whenever it may be necessary to transport smokeless powder ammunition in boats, or to take it on shore, as for boat-gun or field-gun target practice, it must be effectively shaded from the rays of the sun.

Procedure when exposed to sun.

16. Whenever, in particular cases, the terms of the previous paragraph have not been complied with, any ammunition which may have been exposed shall be segregated, and shall, for purposes of tests, inspections, and reports, be regarded as a separate index; and, if on board ship, it shall be landed at a naval ammunition depot at the first opportunity, should there be reason to believe it has deteriorated.

Exposure to high temperatures.

17. If at any time smokeless powder be exposed to a temperature higher than 100° F., a special report shall be made to the Bureau of Ordnance immediately, explaining the circumstances in detail and stating the temperature and the length of time the powder was so exposed.

Wet powder.

18. Smokeless powder that has been wet from any cause whatever must be regarded as dangerous for storage on board ship. Such powder must be completely immersed in distilled water (in which condition it is entirely safe), and must be turned in to a naval ammunition depot without delay, where, upon receipt, it will be scrapped. Each container of immersed powder must be clearly marked to indicate its gross weight and the condition of such powder. In handling powder charges which have been wet, the smokeless powder shall be removed from the powder bags or cartridge cases, the smokeless powder then being cleaned by washing in water to remove any black powder residue, before finally packing in water. The powder bags and ignition charges shall be thrown overboard. The condition to be avoided is shipping smokeless powder and black powder in a wet condition in the same container.

Safety devices.

19. Where safety devices are provided for any form of ammunition, they shall always be used in order to preclude any possibility of accidental discharge.

Service ammunition.

20. Service ammunition is supplied to ships for use in battle only. It is not to be used for drill at the guns, instruction of the personnel that requires opening of charges or projectiles, for testing hoists or conveyors, or for similar purposes, except upon express authority from the Navy Department. It shall be regarded as part of a vessel's outfit, shall be kept distinct from the ammunition issued for gunnery exercises, and shall never be expended in gunnery exercises without the authorization of the orders for gunnery exercises or special instructions from the Bureau of Ordnance. Target practice ammunition may be stowed in the same magazine with service ammunition, but steps shall be taken to prevent the use of the latter in target practice. When service ammunition requires overhaul, authority shall be requested to turn it in to an ammunition depot and obtain a replacement, unless the depot can complete the overhaul and reissue the same ammunition before the ship sails. A periodic overhaul is considered advisable about every three years, but this period is subject to wide variations depending on the condition of the charges, tanks, etc., circumstances under which stowed, and care in handling. The inspector of ordnance in charge of the ammunition depot nearest the navy yard in which a ship is undergoing overhaul should be consulted and requested to have the service allowance of ammunition inspected to determine the requirements for overhaul and replacement, and to provide the data for a report on the condition to the Bureau or Ordnance, when requesting authority to turn it in. It is expressly forbidden for any ship to make additions

Inspection of service ammunition.

to powder bags. All ammunition is issued to the service in such condition that no work, except possibly tightening bag lacings, is required to be done on it preparatory to firing. It is strictly forbidden to remove a fuse from a loaded projectile, as this is a very dangerous undertaking and shall be done only at ammunition depots under special regulation, and when so ordered by the Bureau of Ordnance. Under no circumstances shall any person, except when carrying out explicit instructions from the Bureau of Ordnance, attempt to break down a fuse. Only regularly prescribed fuse setters shall be used for setting time fuses, and regular tools for preparing signaling and subcaliber charges and in breaking down and assembling charges for testing powder.

Target-practice ammunition.

21. Special ammunition is put up and issued for gunnery exercises, called target-practice ammunition, or else certain of a ship's allowance of service ammunition, is designated by the Bureau of Ordnance for that purpose. Such ammunition, provided it is not live ammunition, may, when in the discretion of the commanding officer it becomes necessary, be used for instructional purposes, for testing hoists and conveyors, but not for drill at the guns.

Disposition of unexpended target-practice ammunition.

22. The unexpended portion of target-practice ammunition as may have been issued for a specific gunnery exercise or experimental firing shall be turned in as soon as practicable after such firing to an ammunition depot, preferably the one where it was prepared, unless additional firings are immediately authorized by the commander in chief or director of gunnery exercises. When such additional firings are ordered, the Bureau of Ordnance will be so informed.

Use of proper containers.

23. After opening containers and removing ammunition for firing, when not expended, care shall be taken to return it to the proper containers and not to obliterate the identification marks. Case ammunition repacked in tanks or boxes other than those designated to take it will result in damage to the ammunition. A case recently arose where a ship restowed some shrapnel in boxes not designed for it in such a manner that the time-percussion fuses were moved off safety, the water-tight caps cut, and the ammunition rendered useless and dangerous.

Drill primers.

24. The Bureau of Ordnance supplies each ship having bag guns a number of drill primers, according to her allowance list. These drill primers are for the purpose of testing firing circuits. With the exception of these, primers in excess of an allowance of 10 per gun per year shall not be expended except in actual firing. Drill primers, especially manufactured for the purpose, shall not be used for firing service charges except in case of emergency, as they are not designed to withstand the pressures. In addition to the primers especially manufactured for drill purposes, the following lock primers are designated and authorized to be used as drill primers: Simple percussion, simple electric, combination lock primers with magazine sealed with crimped ring, and any other primers the Bureau of Ordnance may specifically designate from time to time as drill primers. The use of service primers for conducting fire-control drills is not permitted. Cases have occurred where ships have used up more than half of their service primers in preparation for target practice, thus rendering a part of their service ammunition worthless until the supply is replenished.

Disposition of small-arms material.

25. After holding small-arms practice, the officer in charge of a rifle range (or, in cases where no officer has been specifically detailed in charge of the range, the officer in charge of the firing party) shall take steps to have all empty cartridge cases, clips, bandoliers, and packing boxes carefully collected and boxed for landing at a navy yard at the first opportunity. Empty cartridge packing boxes may be used for boxing the empty cartridge cases, clips, and bandoliers. Every precaution shall be taken to see that no live cartridges are boxed with the empty cartridge cases. To this end, it is directed that each box containing empty cartridge cases have a tag securely attached to the outside of the container with the officer's name thereon under whom the packing was done.

Disposition of small-arms scrap material.

26. The empty cartridge cases, clips, bandoliers, and packing boxes accruing from small-arms practice by the Navy or Marine Corps, shall, when turned in at a navy yard, be held for such disposition as the Bureau of Ordnance or the Marine Corps headquarters may direct. When a carload of this material has accumulated, a special report shall be submitted by the navy yard to the Bureau of Ordnance or to the Marine Corps headquarters, whichever may be concerned, requesting instructions regarding disposition.

Service projectiles.

27. Projectiles comprising the service outfit of ammunition shall not be altered or disassembled on board ship, in any of their parts, without explicit instructions from the Navy Department. They shall be kept free from rust, and the paint and lacquer shall be renewed when necessary. The old paint shall be removed before painting in order that the dimensions may not be increased by constant addition to it, and care shall be exercised that no paint is placed on the bourrelet. Projectiles for bag guns of 5-inch and 6-inch caliber are issued with their rotating bands protected by grommets. These shall be removed only when preparing for firing. Since the slings are likely to jamb the hoists, in case they are still in use, they should be removed before sending up the projectiles. When removed, grommets shall be returned to a naval ammunition depot.

Chapter II.

SAFETY PRECAUTIONS.

1. The safety precautions are explicit and allow no recourse except positive compliance. It is difficult to cover every possible emergency which may arise and which, if improperly handled, may result seriously. An attempt should be made in carrying out the safety precautions to grasp the ideas on which they are based so that, under circumstances not known at the time of their promulgation, the proper action may instinctively be taken.

Extent of safety precautions.

2. As a matter of precaution, persons working with explosives shall have no iron, steel, or articles of a combustible nature about their persons. Matches are a source of great danger and should never be permitted around explosives. Smoking should not be permitted during firing or when magazines are open and powder exposed. Particular attention shall be paid to avoiding the making of sparks from contact of steel on steel, especially with black powder present. Black powder is the most dangerous explosive used in the Navy, and the one most likely to cause accidents.

Forbidden articles.

3. A red flag shall be hoisted and kept flying whenever explosives are being handled. All boats and vehicles carrying explosives, except artillery pieces, shall carry a red flag.

Red flag.

4. The safety orders regarding magazines and ammunition are quoted herewith, articles 972, Navy Regulations, 1921.

"**5.** Copies of all safety orders shall be kept posted in conspicuous places easy of access to members of the crew, and all members of the crew concerned shall be frequently and thoroughly instructed in them.

Safety orders.

"**6.** The attention of all officers is invited to the necessity for the continuous exercise of the utmost care and prudence in the handling of all kinds of ammunition and explosives.

Care in handling ammunition.

"**7.** Conditions not covered by these safety orders may arise which, in the opinion of the commanding officer, may render firing unsafe. Nothing in these safety orders shall be construed as authorizing firing under such conditions, or as preventing the commanding officer from issuing such additional safety orders as he may deem necessary.

Conditions not covered herein.

"**8.** When in doubt as to the exact meaning of any safety order, an interpretation shall be requested of the Bureau of Ordnance.

Interpretation to be requested.

"**9.** No naked light, matches, or other flame-producing apparatus shall ever be taken into a magazine or other compartment containing explosives of any kind.

Magazines.

"**10.** All explosives shall be removed from a compartment in or adjacent to one in which it is intended to use an oxyacetylene cutting or welding torch or any similar appliance.

"**11.** Magazines shall be kept scrupulously clean at all times. Particular attention shall be paid that no oily rags, waste, or any other materials susceptible to spontaneous combustion, are stored in magazines or other compartments containing explosives of any kind.

"**12.** Drill charges for bag guns soon become covered with oil and grease, and it is strictly forbidden to store such charges in magazines or other compartments containing explosives.

"**13.** Nothing shall be stored in magazines except explosives, authorized containers, and gear which is actually used to assist in handling ammunition.

Ammunition.

"**14.** Case ammunition, loaded and fused projectiles, or smokeless powder charges, will never be used for drill. This does not prohibit the fitting of case ammunition in a gun previous to firing, provided the firing pin has been removed and the electric firing circuit has been completely disconnected.

"(*a*) No ammunition, or other explosive, shall be used in any gun, or appliance, other than the gun or appliance for which it is supplied.

"(*b*) During the firing no ammunition other than that immediately required shall be permitted to remain outside of the magazines.

"(*c*) In ships fitted with magazine flap doors, only such magazine flap doors as are being used to supply charge shall be open, the flaps, in all cases, being down except during the time of actual passage of the sections of the charge through the door.

"(*d*) Where powder is sent up to the guns from the magazines in bags and not in metal containers, there shall not be removed from its tank, nor shall the top of the tank be left so loosened as to expose the charge to flame, at any time for the gun or guns being supplied, more than one charge each in every one of the stages of the ammunition train. This does not apply where ammunition chain hoists are used, as in this case the hoists may be kept filled.

Gunnery exercises.

"**15.** At gunnery exercises there may be assembled on deck no more than the necessary allowance of ammunition for the intermediate or secondary battery guns that are to fire on the next run; but no charge for a bag gun shall be removed from its tank, nor shall the top of the tank be left so loosened as to expose the charge to flame until immediately before the charge is required for loading. For case guns, the allowance required for the gun or guns that are to fire on the next run may be removed from the boxes.

Ammunition test.

"(*a*) When an ammunition supply test is made, the ammunition used therefor will be that authorized for gunnery exercises unless the order for the test authorizes the use of service ammunition.

Loading tracer fuses.

"(*b*) In loading projectiles fitted with tracer fuses, care shall be taken not to strike the tracer mouth cup of the fuse, as such a blow involves danger of igniting the tracer and thereby an exposed powder charge in the vicinity.

Powder bags.

"(*c*) Under no circumstances shall the material of powder bags be added to without authority. Should it be necessary to stiffen the charges, additional cloth or tape shall not be used, but the lacing shall be tightened. If the powder bag be badly injured, it should be replaced by a new one from the spares on hand.

Subcaliber practice projectiles.

"**16.** Only blind projectiles shall be used for subcaliber practice.

Loading service primers.

"**17.** Service primers shall not be previously loaded in the lock except as may be necessary to test the fit of the primer.

Removing fuses forbidden.

"**18.** Fuses shall not be removed from loaded projectiles, except at naval ammunition depots, until explicit instructions are received from the Bureau of Ordnance.

"(*a*) Any loaded and fused projectile which may be accidently dropped in service from a height exceeding 5 feet should be set aside and turned into a naval ammunition depot at the first opportunity. Such a projectile should be clearly marked to indicate its condition and should be handled with the greatest care. Upon receipt at the naval ammunition depot it shall be unfused and the fuse scrapped.

"(*b*) With one or two exceptions, the fuses in minor caliber projectiles are armed by setback instead of centrifugal action. Care must be used to avoid tapping or otherwise striking projectiles fused with minor caliber fuses. This is particularly applicable to attempts to loosen projectiles in the cartridge case by repeated light blows of a hammer or mallet.

Use of special devices.

"**19.** Gunnery and division officers shall see that the special fittings and devices installed for purposes of safety are in good condition and operative at all times.

Constriction in bore.

"**20.** It is unsafe to fire guns that have a constriction of the bore due to steel. Such a constriction may be caused by gun liners overriding the retaining shoulders. It usually appears in the form of a ring in the immediate vicinity of the liner shoulders near the muzzle, and can usually be seen immediately after cleaning the guns by looking through the bore toward a strong light, the observer moving his point of vision around the end of the bore. The constriction will appear as a ring of light and shadow, and if such is found will be immediately reported to the Bureau of Ordnance. A study of the general arrangement drawings will show the position where such constrictions are most likely to occur.

Working circle.

"**21.** A circle shall be painted on the deck to indicate the limiting position of the breech of the gun on recoil, and the gun crew shall be instructed how to keep clear.

"(*a*) Marks or indicators shall be provided to indicate if the gun returns to battery and a member of the gun crew shall be detailed to observe these marks or indicators after each shot. The service of the gun shall be stopped should the gun fail to return to battery.

Preparations for firing; removal of tompion.

"**22.** In preparing a battery for firing, the division officer shall assure himself that the tompion is removed from each gun, that the bore is clear, and that the gas ejecting system is working satisfactorily.

Filling recoil cylinders.

"**23.** Before the firing of any gun, other than for saluting, the commanding officer shall require a report that the recoil cylinders have been inspected and filled in the presence of the gunnery officer.

(*a*) After filling recoil cylinders not fitted with expansion tanks, the amount of liquid necessary to allow for the expansion of the liquid due to heat shall be withdrawn.

Salvo latch.

"**24.** The salvo latch shall be removed from or made temporarily inoperative on any gun used for drill, and shall be replaced or made operative before such gun is fired. Where no salvo latch is installed, effective measures shall be taken during firing to guard against opening the breech of a loaded gun.

Fire hose.

"**25.** Whenever the guns of a vessel are being fired, the fire hose shall be led out as at fire quarters and pressure shall be maintained on the fire main. This does not require water to be running through the hose.

Precautions when using director fire.

"**26.** When engaged in gunnery exercises with director fire, an observer shall be stationed at one of the sight telescopes of each broadside gun or turret and shall cause the firing circuit to be broken in case the gun or turret is trained dangerously near any object other than the designated target.

Loading bag charges.

"**27.** Especial care shall be exercised to see that all sections of powder charges are entered in the chamber with the ignition ends toward the breech, and that the rear section is touching the face of the breech plug when closed. The other sections shall be placed as far forward as possible.

Broken powder bag.

"**28.** If a powder bag is broken while loading to the extent of allowing powder grains to fall out, the command "silence" shall be given and the loose grains shall be gathered up. If it is impracticable to place the charge in the gun, it shall be sent out of the turret and be completely immersed in water.

"**29.** The mushroom of every bag gun shall be wiped after each shot with a sponge or cloth dampened with fresh water.

Sponging guns.

"**30.** The sponging of case guns is not necessary, but before storing empty cartridge cases below they shall be freed from inflammable gases.

Priming of bag gun.

"**31.** The priming of a bag gun while the breach plug is open is forbidden, and the breech plug shall be closed and locked before the primer is inserted in the firing lock, except in a gun in which the wedge block containing the firing pin is arranged to operate automatically by the functioning of the breech mechanism, in such a manner that the firing pin can not be brought opposite the primer until the breech plug is closed and locked.

"(*a*) When priming locks of the sliding-wedge type, special care should be taken to insure the primer being pushed in beyond the primer retaining catch to prevent the primer coming out or being sheared off by the operation of the wedge in closing.

"**32.** The breech plug of a gun shall never be unlocked or opened while there is a live primer in the lock.

Use of firing lanyard.

"(*a*) If a firing lanyard is used, it shall never be hooked to the trigger of the lock until after the breech plug has been closed and locked and the gun primed. The lanyard shall be hooked just before cocking the lock.

Unlocking breech.

"(*b*) The breech plug shall never be unlocked or opened while the lock is cocked or while the lanyard is hooked to the trigger.

Cease firing.

"(*c*) When the order 'Cease firing' is given, loaded guns must be put in such condition as to render accidental discharge impossible. This necessitates for bag guns the removal of the primer and for case guns the removal of the case. If a crew leave a gun at any time, the gun shall be left in the condition of cease firing.

Locking breech.

"**33.** Every possible precaution shall be taken to prevent a gun from being fired when the breech plug is swung home but not fully rotated and locked. Accidents from this cause are likely to happen with screw breech mechanisms fitted for percussion firing. Where the lock is operated automatically, the automatic functioning of the lock shall not be interfered with in any way. If a gun be fitted for electric firing with the contacts so arranged that the plug must be fully rotated before the firing circuit can be closed, it is not possible for any accident of this kind to happen by electric firing, but it is still possible by percussion firing.

Closing breech.

"**34.** As soon as a gun is loaded, the breech shall be closed without delay.

Unloading warm gun.

"(*a*) When a gun which has been fired is still warm when reloaded and it later becomes necessary to remove the charge, the gun need not be fired but should be unloaded, provided no attempt has been made to fire the gun. If such attempt has been made, proceed as for hangfire. When it is apparent that the service of the gun will not be resumed within a reasonable time, the smokeless powder involved will be completely immersed in distilled water and kept in that condition until turned in to a naval ammunition depot at the first opportunity.

Unloading cool gun.

"(*b*) When it becomes necessary to unload a gun which has not been warm at any time while loaded, the following will be observed: If a case gun, the cartridge will be carefully examined, and if found in good condition, it may be returned again to the magazine; if not in good condition it should be broken down and the powder treated as stated in paragraph 34 (*a*) above. If a bag gun, the charge should be most carefully examined. If found dry, free from grease and in good condition, it may be sent back to the magazine; if slightly greasy, the charge should be rebagged on board ship if spare bags are available; if such bags are not available, or if grease or moisture has in any way gotten into the powder, the charge should be completely immersed in distilled water and treated as directed in paragraph 34 (*a*) above.

Primer premature.

"**35.** There is a possibility of firing primers prematurely by the force exerted by the firing pin on the primer plunger due to successive closings of the Mark XIII, Mod. 1, firing lock on the same primer. Each slight pressure of the firing-pin contact point tends to move the primer plunger forward, and firing by percussion may result from the progressive movement.

Care in repriming. "(*a*) This is most likely to occur when repriming the gun without opening the breech plug, as the firing lock works much quicker and more violently by hand than is possible when working in conjunction with the operation of closing the plug.

Closing firing lock. "(*b*) The design permits the closing of the lock without subjecting any member of the crew to danger from the recoil of the gun. If the lock operating handle can not be safely reached by hand a suitable tool should be employed to close the lock.

Use of force in loading. "**36.** No force greater than that which can be applied by the hand alone shall be used in loading a cartridge case into a gun. Any cartridge case that does not freely and fully enter the chamber of the gun under the influence of the force of the hand alone shall be carefully extracted and put aside. It shall be properly marked to indicate its condition and shall be turned in to a naval ammunition depot at the first opportunity.

Projecting firing pin. "**37.** In every case gun, except those of the sliding-wedge type, the breech plug shall not be closed until the gun captain is assured by actually feeling that the front face of the plug is in normal condition and that the firing pin does not project beyond the face of the plug.

Broken firing pin. "(*a*) The danger of a broken firing pin point or of the fusing of metal on the face of the breech plug, due to a primer blowback, shall be constantly borne in mind.

Defective firing pin. "(*b*) As the firing pin of every concentric screw breech mechanism is directly in rear of the primer when the plug is closed but not rotated, the utmost care shall be taken to insure that the firing pin and all parts are in good condition, as the failure of a part of the mechanism might permit the firing of the gun before the plug is rotated.

Housing firing pin. "(*c*) In a case breech mechansim having the firing pin held in position by a cotter pin, similar to the 5-inch Mark V mechanism, the cotter pin shall be in place at all times, in order to prevent the firing pin from losing its housing. If the firing pin be not housed, a premature explosion is apt to occur.

Removal of firing pin. "(*d*) In all case guns, when live ammunition is being tested, the firing pin shall be taken out.

"(*e*) No case gun shall be fired with a breech mechanism in which the firing pin is not completely housed.

Gas ejection. "**38.** As there is an inflammable gas present in the chamber of a gun after firing which, under certain conditions, may constitute a danger by igniting the powder charge which is to be used for the next round, the following precautions shall be observed:

"(1) Bag guns fitted with approved type of gas ejector which is in good condition shall not be reloaded until a member of the crew, whose duty it is to look through the bore, has been assured himself that the bore is clear and has announced 'Bore clear,' either by voice or by approved signal, such as a whistle, gong, or horn.

"(2) Until the 'Bore clear' signal above described is given, powder shall not be exposed closer than 4 feet from a gun not mounted in a turret. In turrets fitted with ammunition cars, the car shall not be brought above a horizontal plane 6 feet below the axis of the trunnions until the 'Bore clear' signal is given. In turrets fitted for hand passing powder, the powder shall not be exposed in the turret chamber nor shall the flame seal, shutter, or flap between the turret chamber and the next stage in the powder passing train be opened or unlocked until the 'Bore clear' signal is given.

"(3) In turrets not fitted with bulkheads between the guns, the 'Bore clear' signal to the turret crew shall not be given until the guns which have been fired and whose breech plugs have been opened are reported clear, when one signal to the entire turret crew shall be given.

"(4) Bag guns not fitted with approved type of gas ejector and which permit using the combined sponge and rammer shall have the shell rammed home with the combined sponge and rammer dampened with water, and until this has been done the same restrictions on exposure of powder as above laid down before the 'Bore clear' signal shall be enforced.

"(5) Bag guns not fitted with an approved type of gas ejector, or those with gas ejector out of order and which do not permit using the combined sponge and rammer, shall not be loaded until sufficient time has elapsed for the gases in the bore to dissipate, and the 'Bore clear' signal must be given. The same restrictions on exposure of powder as given above shall be enforced.

"(6) The above precautions do not apply to case guns.

Misfire.

"**39.** The possible danger of a serious accident due to opening the breech plug of a gun too soon after a failure to fire demands the constant exercise of the utmost prudence and caution whenever such a failure occurs.

Hangfire.

"(*a*) Whenever an attempt has been made to fire and a gun fails to fire, a hangfire shall be regarded as probable. No distinction shall be made between a misfire due to the failure of a primer to ignite and a misfire due to a failure of a charge to ignite after the primer fired, until it is known if the primer failed to fire.

"(1) In pointer fire extract the primer and examine it to see if it exploded.

"(2) In director fire determine if firing circuit was fully closed. If found fully closed remove and examine primer to see if it exploded.

Delay after misfire.

"(*b*) Except in action, whenever a misfire occurs in a gun an interval of at least 30 minutes shall be allowed to elapse after the last effort to fire the gun before the breech plug is opened, except when, in the case of a gun using a lock primer, an examination of the extracted primer shows it did not fire. In such a case there is no danger of a hangfire, and the foregoing rule need not apply. In case of misfire in field and landing guns on shore, an interval of 10 minutes shall be allowed to elapse after the last effort to fire the gun before the breech plug is opened.

Continued efforts to fire.

"(*c*) Nothing in this article shall be construed as discouraging possible efforts to fire the gun which do not involve opening the breech plug. In bag guns the primer shall be removed (using an appropriate tool in order to avoid the danger of being struck by the recoil or of injury from a blowback), and a new one inserted and fired, using either electric or percussion mechanism, as seems most desirable, and these efforts shall be continued as long as there is a reasonable chance of firing the gun. In case guns efforts to fire shall be continued as long as there is a reasonable chance of firing, either by electricity or percussion, or by both, when such efforts do not require the breech plug to be unlocked or opened.

Misfire in battle.

"(*d*) When possible chance of serious danger due to a misfire may be overbalanced by the more important consideration of battle, the battery or turret officer may, at his discretion, open the breech plug without waiting as required in paragraph 38 (*3*) above.

Disposition after misfire.

"(*e*) If, after removal from the gun, an inspection of the cartridge case shows that the primer has been struck by the firing pin, or in case the misfire occurred in a bag gun, the charge will be treated as prescribed in paragraph 37 above.

"(*f*) In any case the gun while loaded must be kept pointed so that its accidental discharge will do no damage.

Unloading after misfire.

"(*g*) When a gun is being unloaded after a misfire, in accordance with these safety orders, all unnecessary members of the gun crew shall be dismissed from the vicinity of the gun and the unloading shall be personally supervised by the division officer.

Elevation of antiaircraft guns.

"**40.** Unless otherwise specifically authorized, antiaircraft guns on board ship shall not be fired during gunnery exercises or test firings at elevations greater than 80°, on account of the erratic character of trajectories at high angles of elevation.

Morris tube.

"**41.** No Morris-tube practice shall be held without an efficient bullet catcher securely attached to the muzzle of the gun or otherwise suitably secured in the line of fire of the small rifle."

Steaming out oil tanks.

42. The following additional interpretations should be placed on certain of the above-quoted orders:

(*a*) The removal of ammunition from a magazine should be effected when adjacent compartments are steamed out, or when the temperature is increased above 100° F. for any other reason. See paragraph 9.

Unauthorized use of magazines.

(*b*) The use of magazines not required for storage of ammunition shall not be diverted to other uses except on authority from the Navy Department. Cases have occurred where inflammable materials have been stored in empty magazines separated by a bulkhead only from a part of the ship's service allowance.

Ready-service magazines.

(*c*) When ammunition is stowed on deck in ready service magazines adjacent to the guns, care should be exercised to see that it is not exposed to the sun or to high temperatures. When the temperature in a ready service ammunition box reaches 100° F., the ammunition shall be removed or steps taken to reduce the temperature below 90° F. as though the ammunition was in a regular magazine.

Unloading case guns.

(*d*) When a live cartridge has been unloaded from a case gun, if found not in good condition, it shall not be thrown overboard, but shall be broken down, the powder immersed in distilled water and the disassembled round turned in to an ammunition depot. See paragraph **34** (*a*).

(*e*) Primers which fail to fire or which appear to be in bad condition when a box is opened shall be segregated and turned in to an ammunition depot for investigation. **Defective primers.**

(*f*) With a bag gun after a misfire the powder shall be removed and immersed in distilled water. Before immersion the powder in water, the powder bags shall be opened and the powder dumped in a water-tight container, and water poured on it sufficient to cover the powder. The powder bags with the ignition charges will be thrown overboard. With a case gun the cartridge shall be broken down, if the inspection shows that the primer has been struck by the firing pin, and the powder immersed in distilled water. **Immersing powder in water.**

(*g*) When powder has been immersed in water it shall be frequently inspected to see that all is covered and additional water added to insure this.

Chapter III.

DEFINITION AND HISTORY OF EXPLOSIVES.

Explosion and explosive.

1. The term explosion is very broadly used to define a bursting with great violence and loud noise, thus covering many occurrences resulting from the action of other substances than those known as explosives. The most important effect of an explosion is a rise in the pressure in the surrounding medium. Although an explosion results from the rupture of a cylinder filled with gas under pressure, the gas is not considered an explosive substance as the action produces a fall in pressure. An explosive substance, on the contrary, produces a rise in pressure. Marshall defines an explosive as follows:

> "A solid or liquid substance or mixture of substances which is liable on the application of heat or a blow to a small portion of the mass, to be converted in a very short interval of time into other and more stable substances largely or entirely gaseous. A considerable amount of heat is also invariably evolved, and consequently there is flame."

It is characteristic of an explosive that when the explosion occurs it is always accompanied by a chemical transformation. "Explosives have also been defined as substances whose atomic groups are in unstable equilibrium." ("Explosives," Brunswig, Munroe & Kibler.)

Conditions for an explosion.

2. There are three important conditions to be fulfilled by an explosive substance; first, to produce large quantities of gas; second, to liberate heat; and third, to accomplish these two conditions in a very short space of time. If gases are evolved slowly, they are dispersed without causing any noticeable increase in pressure, such as happens when oil, for instance, is consumed in the ordinary way. Yet petroleum has 30 times the latent power of fulminate of mercury. A chemical reaction may liberate large quantities of heat such as is the case with thermite, yet not evolve gaseous products, hence it can not be classed as an explosive substance. It is therefore essential that pressure result from the sudden decomposition of an explosive substance. The volume of gas evolved is so great compared with the original mass that a sudden pressure results, expending the energy released in the surrounding medium, manifesting itself in the disruptive phenomena accompanying an explosion.

Explosive reaction.

3. The chemical transformation taking place in an explosive reaction is an oxidation process of a kind which liberates heat, i. e., an exothermic reaction. If heat were not liberated, the absorption of energy due to the work done by the explosive would cool the explosive and slow down the reaction until it ceased, unless heat were supplied from without. Once the reaction is started the heat liberated tends to propagate the explosion. An explosive substance may be considered as containing a certain amount of latent chemical energy, which is released on decomposition in an almost instantaneous oxidation process. This means that the substance must contain sufficient oxygen to combine with the other elements to form the gaseous products. Carbon and hydrogen are the elements the oxygen reunites with to form water, carbon dioxide and carbon monoxide, depending on the amount of oxygen present. The oxygen is not combined with the carbon and hydrogen until the reaction occurs, but is present either as a separate compound, as in the saltpeter in black powder, or combined in a single compound, as in a nitro explosive in which the nitro radicals act as the oxygen carriers. This distinction in the method of supplying the oxygen divides explosives substances into two classes: *Explosive mixtures*, consisting of distinct substances mechanically mixed together, and *explosive compounds*, which are of definite homogenous chemical constitution. each molecule having the elements necessary for combustion. As a rule few explosives have sufficient oxygen present to oxidize all the carbon to carbon dioxide, but when they do, a very high temperature results, as may be seen from the following. If 12 grams of carbon unite with 16 grams of oxygen to form 28 grams of carbon monoxide, 29 large calorics of heat are liberated. If 12 grams of carbon unite with 32 grams of oxygen, then 97 large calorics of heat are liberated. This influence of the products of combustion on the power of explosive substances is shown by the difference between nitroglycerin, which has an excess of oxygen (more than is required to convert all the carbon to carbon dioxide), and nitrocellulose, which has a deficiency of oxygen such that only small quantities of carbon dioxide are formed.

Explosive mixture and compound.

Heat of explosion.

4. It might be supposed that the quantity of heat given off by an explosive is large, but this is not the case, as is shown by the following table giving the relation of certain articles to each other with reference to the amount of heat given off in combustion.

Petroleum	**30**
Coal	**20**
Wood	**8.75**
Nitroglycerin	**4**
Fulminate of mercury	**1**

Explosives appear to contain more energy for the reason that they have the property of releasing their energy in an extremely short space of time—that is, the velocity of explosion or the rate at which the effects of the reaction are transmitted from layer to layer is very great. Although the quantity of gas and heat evolved affect greatly the power of an explosive, the rate at which they are given off is of prime importance. This rate is measured by taking the time the explosive wave requires to travel a known distance in a tube in which the explosive has been packed.

Sensitivity.

5. The sensitivity of an explosive is an important property. The substance must be "safe" until the impulse is applied to start the reaction. If the atemic groups are in such an unstable equilibrium that the reaction starts spontaneously, or in response to a slight blow, the substance can have no practicable application. Explosives vary in the strength of the impulse required to cause them to explode. Some are exploded by the slightest touch; others, such as fulminate of mercury, require a moderate blow or a flame, and others require a very violent blow and can not be exploded in the open by a flame. It was originally considered that the power of an explosive was measured by the sensitivity and that the most powerful explosives were quite sensitive; but now, in the light of modern investigation, it is found that insensitive explosives are quite powerful and that the *safest* explosives are those which under ordinary circumstances require a detonator to initiate the reaction. Of these explosive "D" and T. N. T. are examples.

Classification of explosives.

6. Explosives can not be classified definitely from their chemical constitution, by the gas evolved or the heat liberated. Consequently, they are classified by the speed of the chemical change. If the velocity of explosion can be controlled after the reaction starts, the explosive is classed as a propellant, i. e., for use in ejecting a projectile from a gun. One not in this class is termed a "high explosive." A propellant is sometimes termed a low explosive and is one which burns relatively slowly and permits of initiating the action by flame. When an explosive requires a powerful agent, such as fulminate of mercury, to start the reaction, but which when once started proceeds at a high rate, it is considered a "high explosive." The latter have a powerful disruptive action. The velocity of explosion for a smokeless powder is about a meter per second, for black powder about a few hundred meters per second, and for high explosives several thousand meters per second, depending on the conditions under which the reaction occurs.

Propellant and high explosive.

7. From the above it may be judged that the difference between a propellant and a high explosive can not be sharply drawn. In fact, until nitroexplosives came under investigation, there was no need of such a distinction, as black powder was the only well-known explosive substance and was used both for propellant and blasting purposes. It would be possible to use any explosive for propellant purposes if the velocity of explosion could be controlled. Investigations along this line caused the development of smokeless powder as we know it to-day, for nitrocotton, when attempts were made to use it as a propellant charge, did considerable damage to the guns. However, when it was found that when this high explosive was dissolved in ether and alcohol the colloid resulting burned instead of detonated, a revolution in the propellant explosives industry began. The number of chemical compounds which can be so treated as to permit control of the velocity of explosion is very small, and is still more limited by the fact that the substance in its final state must not only be efficient ballistically, but must be safe in use, easy to handle, and stable under varying conditions of storage, and also remain in a stable condition for protracted periods of time. When selecting an explosive, it is necessary to consider the ease and safety of manufacture and use, the cost, the sensitivity, the power, the stability, and the temperature of explosion.

Requirements of an explosive.

Early history.

8. Various attempts have been made through search of the works of the fourteenth and fifteenth century writers to determine with some degree of certainty the early history of gunpowder and its use in military operations. Due to the inaccuracies of the manuscripts, the fanciful style of many writers of that day, and to the errors in translation and loose use of terms, not only is it impossible to name the inventor, but it is also a matter of conjecture as to which nation belongs the credit for its invention. It seems most probable that gunpowder as used in the fourteenth century was the result of the gradual development of the substance known as "Greek fire" and "wildfire" by the addition of saltpeter when this substance was found to have the property of deflagrating with burning bodies.

Greek fire.

9. In 660 A. D., in the defense of Constantinople, a mixture thought to contain sulphur, pitch, resin, etc., was discharged from a tube or siphon somewhat after the manner of modern flame projectors. The tubes were mounted in the bows of the Greeks ships and destroyed the enemy by directing a burning stream of liquid fire at them. The secret has not survived the ages, but a similar substance appeared at a later date, about the time of the sixth crusade, as "wildfire." In this, sulphur, naphtha, pitch, and saltpeter, in a semisolid mass, was ignited and thrown by ballistæ in land warfare.

First use of black powder.

10. From the best authorities it appears probable that the Arabs about 1280 A. D. used mixtures similar to gunpowder by substituting charcoal for the naphtha, and that about 1313 A. D. the gun for the use of black powder was invented by a German monk named Schwarz. The use of gunpowder was not extensive at first, as its employment was not in accord with the chivalrous sense of the times, but when it finally was adopted its use spread rapidly, resulting in improvements in manufacture and rapid development of powder-making machinery. It was restricted in use in the early stages, as it was prepared as a fine powder, and consequently was suitable only for use in small arms, but in the sixteenth century the French began to grain it and classify it according to size, so that it could be used in various sizes of guns. In the seventeenth century its use was adapted to the blasting of rock for getting out minerals.

Development of black powder.

11. Until a few years ago gunpowder was the only propellant in use for firearms. During the long period since its introduction it has changed but little in its ingredients, though many changes have been made in methods of manufacture and in its final form. By the introduction of rifled cannon and the increase in pressures for large ordnance the necessity for controlling the rate of combustion became apparent. General Rodman, United States Army, in 1860 inaugurated the method of pressing the powder into different size grains and later of controlling the rate of burning by perforating the grain, thereby improving the ballistic qualities. The next change was the introduction of charcoal from rye straw which resulted in the brown or cocoa powder, so named on account of its color. This improvement gave a denser grain, more suitable for heavy guns as it burned more progressively. In 1882 guns had increased to 16 inches in diameter in the British Navy.

Nitrocompounds.

Guncotton.

12. During the nineteenth century a great development in explosives resulted from the discovery that when certain organic substances were treated with nitric acid easily combustible substances were obtained. In 1838 Pelouze discovered that an explosive could be made by treating cotton with nitric acid. Previous to this, in 1832, Braconnet found that starch, wood, and similar substances treated with nitric acid made explosive compounds. These discoveries were without practicable importance until Schönblein in 1845 found that a mixture of nitric and sulphuric acids produced a better quality of explosive than nitric acid alone. Considerable interest was shown this development by several European countries, resulting in the erection of several factories. Due to the fact that no one knew how to purify the nitrated cotton, and as very little attention was paid to the purity of the ingredients, the stability was very low and many disastrous explosions occurred. In 1853 Von Lenk showed that the trouble lay in the purification and suggested that instead of merely washing the nitrated cotton with water until neutral that an extended course of washings was necessary, including boiling with dilute potash solution. In spite of Von Lenk's improvements explosions still occurred. Meanwhile, Abel continued experiments and 1865 found that there was great virtue in a pulping process in that the treatment reduced the impurities and also permitted pressing the pulped material into blocks. In 1868 it was found that when wet it could be detonated by dry guncotton and that the dry guncotton could be detonated by fulminate of mercury. This resulted in its adoption for military purposes for explosive charges.

Nitroglycerin.

13. In 1846 Sobrero discovered nitroglycerin. This substance, due to its dangerous nature and difficulty in causing it to explode, was not developed until Nobel in 1859 found that it could be detonated by fulminate of mercury. In 1867 he found that by allowing keiselguhr to absorb about three times its weight of nitroglycerine a satisfactory and fairly safe explosive resulted. This substance, known as dynamite, has become very popular and entirely replaced black powder as a blasting agent. In 1875 Nobel invented blasting gelatine, made by solidifying nitroglycerine by the addition of 8 per cent of nitrocellulose.

Other nitrocompounds.

14. As the new blasting powder replaced black powder in commercial uses, so the continued investigation of nitrocompounds produced a substitute for it as a military bursting charge for projectiles. Picric acid or trinitrophenol was adopted by many countries for this purpose; by France in 1885, by Germany in 1888, and about the same time the British Government adopted molten picric acid as Lyddite. In 1905 the United States Navy adopted ammonium picrate, a more insensitive compound than picric acid. In 1905 the German Government adopted trinitrotoluol. Since that time numerous additional compounds have been investigated and adopted.

Substitute for black powder.

15. Inventions up to this time had developed suitable high explosives but these were not suitable for use in guns due to the violence of the explosion. Attention was directed to modifying the known explosives for use as propellants and to the development of smokeless powders. Black powder was considered unsuitable for several reasons, namely:

First, it left a large amount of residue, thus fouling the bore.

Second, made large quantities of black smoke.

Third, was very hygroscopic.

Fourth, caused considerable erosion by the high temperatures of combustion.

Early smokeless powders.

16. The first successful smokeless powder was made by Major Schultze, of the Prussian artillery, about 1864. It was made of nitrated wood impregnated with saltpeter. Later the substance was dissolved in ether and alcohol and was known as collodion. This powder burned fairly slow and as it did not cause as much recoil as black powder and gave no smoke it was very popular for sporting powders. In 1882 the Explosives Co. of England patented the E. C. powders. These were made of nitrocellulose mixed with nitrates of potassium and barium and partially gelatinized by dissolving in ether and alcohol. This powder also is used as a sporting powder, for it is too quick for rifled guns.

Nitrocellulose and nitroglycerine powders.

17. Although Maynard in 1843 discovered that nitrated cotton was soluble in ether and alcohol mixed together, but not in either alone, this fact was used only for development of celluloid and collodion, the latter giving impetus to developments in photography. In 1884 the French engineer Vielle discovered that the fiber of the nitrocotton must be entirely destroyed in a complete gelatinizing process. He mixed nitrocellulose with ether and alcohol and then rolled the mixture into sheets and cut the sheets into cubes. When dried, a very satisfactory propellant powder resulted. This powder was called "Poudre B" after General Boulanger, a noted French ballistician. In 1888 Nobel produced a new propellant which was adopted by the British the same year under the name of cordite. It is a mixture of nitroglycerine and nitrocellulose dissolved in acetone. The improvements which have been made in smokeless powders since that time have been principally in the direction of better purification and other measures for insuring chemical stability.

18. In 1889 the German Government adopted a nitrocellulose powder and in 1893 the Austrian Government adopted a powder similar to cordite. In 1896 the United States adopted the nitrocellulose powder, but it was several years later before it had finally replaced the brown powder then in use.

Adoption of new propellants.

19. Every nation now uses as propellants substances obtained from nitrocellulose, alone or mixed with nitroglycerin, as such substances permit of controlling the rate of explosion, as, during combustion, the individual grains burn from the surface inward in successive layers. By altering the shape of the grain and changing the burning surface the time of the explosion can be modified so that the same composition may be used in any size firearm merely by a change in the finishing process.

Further development.

20. Just as the introduction of smokeless powder has removed the objectionable features of black powder, so we may look to the future to remove some of the objectionable features of smokeless powder, such as the reduction of the flash at the muzzle, the reduction in the temperature of combustion to reduce erosion, and the rendering of it impervious to ordinary changes of temperature and hygroscopicity.

Chapter IV.

BLACK POWDER.

Composition.

1. Saltpeter, sulphur, and charcoal have been the ingredients of black powder from the time of its first use as an explosive. The proportions have varied with the development of the manufacture, from a clearer knowledge of the properties of the different mixtures, so that eventually special proportions were used for making military, sporting, or blasting powders. The earliest mixtures had equal parts of saltpeter, sulphur, and charcoal. Experience obtained by testing different proportions caused a constant change until Berthelot found that 84 parts of saltpeter, 8 parts of sulphur, and 8 parts of charcoal were the theoretically correct proportions. Theoretical results, however, can not be obtained from the combustion of black powder, as it is a mechanical mixture and not a chemical compound, and consequently the combustion is affected by the degree of incorporation of the ingredients. It has been found that an increase in sulphur improves the keeping qualities and that as charcoal is never pure carbon its percentage must be increased. The proportions now used by all nations are practically the same—75 parts of saltpeter, 10 parts of sulphur, and 15 parts of charcoal—these proportions being used for all powders and the rate of combustion for different uses being regulated by the granulation.

Saltpeter.

2. Saltpeter is formed in nature by the decay of nitrogenous substances in the presence of air, moisture, and alkalies, more readily in warm climates, as the higher temperatures facilitate the decay. The most fruitful source was India, but European countries supplied considerable from stables, cattle sheds, etc., where stable dung accumulated. Frequent sprinkling with urine accelerated the decay. In France, England, and India saltpeter collecting became a regular trade, and as its importance was paramount for providing powder for the military the workers were given special privileges, even to the extent of being permitted to remove material from any stable or house with or without the consent of the owner.

Sources of saltpeter.

3. The material when gathered is placed in containers and sprinkled with water. The liquid flowing through the mass dissolves the saltpeter and carries it off to evaporating containers, where it crystallizes out. The result is a crude saltpeter, which is removed to refineries and treated in a similar process more subject to control. With the discovery of the sodium nitrate deposits in Chile another source was obtained. This salt is treated with potash or potassium chloride in the concentrated mother liquid from a previous operation, and sodium chloride or common salt crystallizes out at the high temperature of the reaction. When cooled the saltpeter which has been formed crystallizes out.

Sulphur.

4. Up to a few years ago sulphur was obtained from the Sicilian sulphur mines, which produced a limestone ore with about 25 per cent sulphur. The ore is piled in heaps covered with moistened ashes and a fire started at the bottom. The combustion of some of the sulphur after the fire has started provided the necessary heat for melting the rest, and as the molten sulphur runs out the bottom it is collected in troughs, where it forms sulphur cakes when cool. More recently it has been obtained to some extent from coal gas, but by far the best and most abundant source is the sulphur fields of Louisiana. The sulphur is found there in a very pure state at a depth of about 500 feet, but its removal at first presented many difficulties, as it was beneath quicksand. A method was successfully adopted of driving a large pipe down into the sulphur bed. A smaller pipe was placed inside this, both being perforated at the bottom. Superheated water is passed down the outside pipe and melts the sulphur, which then passes up the inner pipe, assisted by air pressure, to the surface, where it is allowed to flow into bins and cooled. The product obtained is practically pure sulphur. Due to the cheapness of the product obtained in Louisiana, Sicilian sulphur could not compete with it, and the mines would have been abandoned except for the action of the Italian Government in supporting the industry.

Source of sulphur.

Effect of sulphur.

5. Sulphur has the effect of making black powder burn more readily, as its ignition temperature is low. It also has the effect of flowing when under pressure of manufacture, so that it cements the charcoal and saltpeter together.

Charcoal.

6. Soft wood is usually burned to make charcoal for powder, as it is easier to ignite than if made from hard wood. A variety of woods have been used, such as the alder, dogwood, yew, and willow. In the United States the willow has generally been used, and it is to be noted that black-powder factories are now located where the willow trees grow in abundance. The wood is carefully selected, cut in the spring, and the bark removed. Then it is seasoned until the sap has run out. The wood is split up, placed in iron cylinders and heated uniformly in a furnace at a temperature of about 280° C. The volatiles are allowed to escape through holes in the cylinder and into the furnace where they burn. When the flame from the escaping gas becomes blue, the carbonization has proceeded far enough. The cylinder is removed, the contents kept from contact with air, as oxygen would cause the heated carbon to burn, and when cool the charcoal is removed, sorted, and ground. The charcoal for brown powders was made from rye straw, only slightly carbonized, resulting in a soft material with a large percentage of hydrogen and oxygen. Rye-straw charcoal in the process of pressing had the effect of binding the other ingredients together and thus made a denser grain, giving better ballistic results in large guns, as the denser grain burned more slowly. Brown powders made from rye straw have been entirely replaced by smokeless powder, so that its manufacture has entirely ceased.

How prepared.

Manufacture of black powder.

7. The most important considerations in manufacturing black powder are to have the ingredients finely pulverized, intimately mixed together, and pressed to a high density. Manufacturing methods have changed considerably since the original process of pulverizing, mixing, and caking in one operation (which was discontinued due to dangers involved). At the present time they still differ a great deal in dif-

Pulverizing. **Mixing.**

ferent countries. The saltpeter, sulphur, and charcoal are first ground separately to a very fine state in a mill without danger, as separately they are not explosive. This may be done either in separate operations or by mixing them together in varying proportions before grinding. The French method is to grind 6 per cent of the saltpeter with the charcoal and the rest with the sulphur, and then mix the compounds. Usually some saltpeter is added to the sulphur to prevent it caking during the pulverizing process. Any mill is suitable for the pulverizing operation, but the one in most general use consists of a steel cylinder in which are placed bronze balls and the materials, the balls reducing the material as they fall with the rotation of the drum. After pulverizing, the ingredients are weighed out in the proper proportions and given a preliminary mixing in a drum made of wood, leather lined, in which are placed lignum-vitæ balls, or in a copper cylinder through which an axle passes carrying several rotating arms. The mixing is carried on by rotating the drum or cylinder for five minutes.

8. At this stage in the manufacture the black powder takes on its explosive character, and all further operations must be carried out most carefully to prevent friction or sparks igniting the material.

Incorporation.

9. The incorporating is now usually done in incorporating mills, which consist of two heavy stone wheels running on a stone bed. They both may be made of iron, in which case the wheels are suspended from a crosshead, so as not to touch the bedplate. As the crosshead is revolved by means of a vertical shaft, the wheels travel round and crush and grind together the ingredients without exerting on them force sufficient to cause an explosion, provided the mill is properly operated. Scrapers are fitted to brush the charge under the wheels. The charge is spread over the bed evenly and wet down with about 3 per cent of its weight in distilled water. The grinding is carried on for about two hours for cannon powder, and up to five hours for rifle powder, water being added periodically to keep it moistened. On completion of the incorporating process, the powder on the bed is in the form of mill cake. This must be carefully removed, broken up by hand or by a breakdown machine to reduce it to the powdered form for pressing.

Pressing. **Graining.** **Glazing.**

10. In the pressing or caking operations, several layers or cakes are formed with copper, bronze, or ebonite plates between layers of powder, the latter being about ¾ inch thick. The built-up charge is then placed in a hydraulic press and a pressure of about 400 pounds per square inch applied and held for about three-quarters of an hour. On removal the outer edges of the cakes formed are cut off and added to the next press charge, and the remainder are broken and passed through the granulating machine, which consists of three or four pairs of gun-metal rollers through which the cake is passed. A number of automatic sieves are fitted for sorting out the grains according to their size. After granulating, the powder is given a glazing treatment; that is, each grain is given a smooth finish, rough edges are rubbed off, and it gets a high polish. This operation consists of rotating the grains in a wooden barrel for about four hours, the time varying with the size of the grain. Large grains are frequently coated with graphite. The rubbing together of the grains produces the glaze. Glazing stops up the pores, thus making the powder less sensitive to moisture, and also makes it less liable to deposit dust. The powder is then dried in canvas trays in houses heated by low pressure steam at a temperature of 40° F., and is then "dusted" by rotating it in a canvas-covered reel, and finally it is blended.

Compressed grains.

11. The above description applies to rifle, cannon, and shell powder, which is made up of irregularly formed grains. When black powder was used as a propellant in heavy ordnance, the mill cake was cut into cakes, or it was powdered and formed into individual grains of a regular size. The sphero-hexagonal powder in use at present for torpedo impulse and depth charge throwers is made in this way.

Physical properties.

12. Black powder was originally used in the powdered form, but when so used is very dangerous to transport. Black-powder dust should always be avoided. A clean white handkerchief wrapped around the fingers and passed through black powder should come out clean, otherwise too much dust is present. Granulating the material makes it more inflammable, as the flame can travel more readily through the interstices. Compressing the powder into large grains, on the other hand, reduces the number of interstices and slows the burning. Perforating these grains permits speeding up the burning, for, as the compressed powder burns from layer to layer, the surface is increased by the enlargement of the perforations. General Rodman made disks the diameter of the bore and about 1 to 2 inches thick, with perforations, and obtained great success in controlling the rate of explosion.

Packing.

13. Black powder is packed in metal drums, which have an interior cloth bag lining.

Uses.

14. Although the introduction of new chemical compounds has limited the present use of black powder, it is still found to be most serviceable for a number of purposes. It remains as the explosive charge of many projectiles, as the propellant charge for shrapnel balls, above water torpedo tubes and depth-charge throwers, for blank charges, for time trains in time fuses, for ignition charges for smokeless powder, and for use in primers of various kinds. Its most serious objection is that it deteriorates with increased moisture in a very irregular manner; consequently, it is very important that it should always be protected from a moist atmosphere. On the other hand, it has the decided advantage of high stability at moderately high temperatures.

15. The following table gives the grades of black powder and its use in the United States Navy:

BLACK POWDER.

Type.	Designation.	Use.
Fine grain	F. F. G	Primers.
Do	F. F. F. G	Do.
Granular	Cannon	Ignition charges.
Do	Shell (larger than cannon)	Projectile fillers.
Grained	Spherohexagonal	Impulse charges.

Chapter V.

SMOKELESS POWDER.

1. As previously stated, nearly all nations use propellant powders made from nitrocellulose, either alone or combined with nitroglycerine. The nitrocellulose from which Navy-standard smokeless powder is made is obtained by the nitration of cellulose in the form of cotton. Cellulose is the fiber structure or cellular tissue of plant growth. It is seldom found in the pure state, but can be extracted from young and tender shoots. It occurs in a more nearly pure state in cotton, linen, or fine paper than in any other form. The study of cellulose is a very complicated one and can not be said to have been exhausted. This complexity is due to the fact that cellulose comprises a series of substances not distinctly separated, which by treatment are merged into one another. Cellulose obtained from different sources shows variations, although the composition is the same. In the purest available form (cotton) certain impurities are present which can not be entirely removed, for in the process of purification the cellular structure is attacked and a loss in pure cellulose results. It is dissolved by strong sulphuric acid, not affected by hydrochloric acid, and forms a series of substances when acted on by nitric acid called cellulose nitrates or nitrocelluloses. It is known by the chemical formula ($C_6H_{10}O_5$), but researches have shown, from its action in forming compounds with nitric acid, that it must be represented as a multiple of this empirical formula. When nitric acid is brought into contact with cellulose, as when nitrating cotton, a nitrate is formed in which the NO_2 group replaces the H_2O group. The amount of the replacement depends principally on the strength of the acid and the temperature and duration of the action. As the result of much investigation, it has been found that no definite stage of nitration occurs such that the cellulose nitrate may be expressed by a chemical formula, although it was formerly known as trinitrocellulose. At present it is believed that the nitration is a continuous process resulting in a product containing any percentage of nitrogen from 6 per cent up to almost 14 per cent, depending on the concentration of the acid, temperature, and other conditions of nitration. For use in explosives, cellulose nitrates are divided according to the percentage of nitrogen into high and low nitration products. The latter, below about 12.7, are entirely soluble in ether and alcohol, while the former, above this nitrogen content, are insoluble in ether and alcohol. Soluble nitrocellulose is the base of United States Navy smokeless powder, while the insoluble variety is used as a high explosive under the name of guncotton.

Cellulose.

Cotton.

Cellulose nitrates.

Soluble and insoluble nitrocellulose.

2. The percentage of nitrogen in a nitrocellulose is a measure of the power of the explosive, hence the necessity for so treating cotton in the manufacture of

Nitration.

guncotton that the highest degree of nitration is obtained. A nitrocellulose of 12.7 per cent may be obtained by treating cotton with nitric acid alone, but to obtain a high nitration product it is necessary to use a mixture of sulphuric and nitric acids. The sulphuric acid does not take part in the final reaction, but combines with the water set free, thus preventing dilution of the nitric acid. The chemical processes are not established beyond question, but it is supposed that the sulphuric acid acts first on the cotton-forming cellulose sulphates and liberating water and the nitric acid then acts on the sulphates, displacing the sulphuric acid and forming cellulose nitrates. The usual proportion for making insoluble guncotton is three sulphuric to one nitric acid, and for soluble two sulphuric to one nitric.

3. As practically the entire amount of nitrocellulose now made is used as the base for smokeless powder, in consequence of which it must be soluble, it is made with less than 12.7 per cent N. The standard Navy practice requires 12.6 per cent ±.05.

Other nitrocellulose substances.

4. Other substances made from nitrocellulose are celluloid, films (photographic), varnishes, artificial silk and ivory, and a preparation called collodion for surgical dressings. Substances such as paraffin, camphor, and other inert materials are added in the manufacture of these substances to render them less liable to explosive action.

Linters and hull shavings.

5. The best grades of long-staple cotton were used for the manufacture of nitrocellulose until it was found that a cheaper grade of cotton waste or of linters would serve the purpose just as well. All cotton in the natural state contains certain impurities such as oil and dirt, which must be removed before it is subjected to the nitration process. As pulping has improved the product, the use of finely cut waste presented no difficulties and was considerably cheaper. After the long staple fiber is removed in the ginning process, the cottonseeds retain about 10 per cent of a short fiber cotton which is called linters. It is removed by passing the seed through another machine. After the removal of the linters a small amount still remains called "hull shavings." Both of the latter, when properly purified, are suitable for nitrating, but as a rule they are mixed in some proportion as 40 per cent shavings and 60 per cent linters. Tissue paper and purified wood fiber may also be used. It is reported that Japan is using wood cellulose, and it is known that Germany used wood cellulose during the World War. Wood cellulose requires careful preparation, wherein the wood is finely pulped and boiled in a solution which destroys the noncellulose.

Purification of cotton.

6. The cotton is given very careful purification treatment, for on this point as well as the purification of the nitrated cellulose depends the stability of the finished product. When removed from the seed it contains certain oils and fatty matter which must be extracted. This is done by means of a solvent. The cotton is then boiled in a weak solution of caustic soda and afterwards washed first with warm water and then with cold water several times to remove all traces of the soda. About a 5 per cent solution of soda is used and if an acid bath is given afterwards not over 0.1 per cent acid should be used as a neutralizer. Bleached cotton is found to be most satisfactory. The bleaching is done by washing in a weak solution of bleaching powder or sodium hypochlorite and then treating with a weak alkali solution to prevent overbleaching, which causes unstabilized products. The cotton is delivered in 500-pound bales and must be clean, uniform, free from lumps, and not contain over a trace of lime, chlorides, nitrates, or sulphates.

Cotton-fiber structure.

7. If a piece of cotton fiber be looked at under a microscope it looks like a piece of twisted yarn, but after nitrating the fiber straightens out. This is caused by a relieving of the skin pressure. If a piece is split open and looked at under a microscope with a magnification of 1,000, there is seen an inner and outer cuticle, and some material between which is the true cellulose held in place by the cuticle. In the purification process this inner part is not reached by the reagents and so contains the impurities. From investigations of a German scientist it is known that the cotton fiber has no free passage up the center, and consequently impurities can not be removed from this portion of the fiber. This makes it necessary to have the pulping process in which the cotton is cut up into minute pieces, thus exposing the inside of the fibers to treatment.

Sulphuric acid.

8. Sulphuric acid is produced by burning sulphur or iron pyrites containing a large percentage of sulphur in an excess of air, thus producing oxygen, nitrogen, and sulphur dioxide. The gases are collected, cleaned, filtered, and passed over magnesium sulphate in the presence of platinum, where another atom of oxygen is taken up, making sulphur trioxide, SO_3. This gas is then passed through weak sulphuric acid, where it combines with the water in the acid to form a more concentrated product. This is called the contact process.

9. The sulphur burner (fig. 1), consists of a horizontal cylinder arranged to rotate about a turn and a half a minute around its axis. At one end is a hopper which feeds sulphur through the shaft by means of a worm feed. Around this end of the cylinder are a number of ports for supplying air for combustion. At the other end connected to the cylinder is the combustion stove or chamber, from which the gas line leads. As the sulphur burns, SO_2 is formed, with some SO_3, and this is drawn by suction through the gas line to the coolers, passing through a series of reverse bends called the dust catcher. The cooler consists of lead pipes for conducting the gas, sprayed on the outside by water. The gas is then further purified by passing it through the scrubbers, which are box-shaped receptacles, containing charcoal, then to a filter consisting of a lead cylinder with baffles in it. Weak acid flows through one way and the gas in the opposite direction. Any gas that is changed into acid flows off. The gas is passed through another coke scrubber and then through a mineral wool filter to remove finally any dirt or impurities. (Mineral wool is formed by blowing steam through the molten cinder from a blast furnace.) There is a centrifugal pump in the line at this point, which keeps a suction on the system from the sulphur burners and forces the purified gas into

the preheaters. The preheater is a coal-fired furnace which heats the SO_2 gas up to about 435° C. It then passes to the converter, which is a large cylinder filled with a sludge formed by magnesium sulphate and platinum placed on baffles. The SO_2 takes up another atom of "O" in the converter, due to the catalyzing effect of the platinum. The SO_3 gas is then passed, after cooling, into the absorber which is a vertical cylinder filled with quartz. Weak sulphuric acid is allowed to trickle down from the top and as it meets the SO_3, which enters the bottom, it takes it up to form stronger H_2SO_4. Excessive acid, as it forms, is blown out to storage tanks.

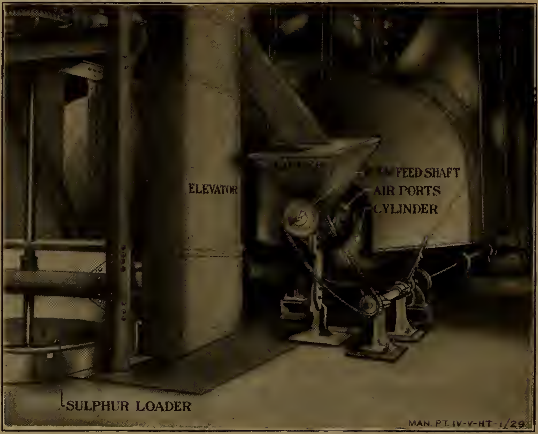


Fig. 1.—Sulphur Burner.

Nitric acid.

10. Nitric acid is mainly obtained either by the action of H_2SO_4 on sodium nitrate, from nitrogen compounds from the nitrogen in the atmosphere, or from certain by-products of the coke-oven industry. In the former method a retort is charged with the required amount of sodium nitrate, ground and dried, and the sulphuric acid is run in. About 6 parts by weight of 99 per cent acid to 5 parts of nitrate are required. A fire is started under the retort and the charge is distilled, the reaction resulting in nitric acid fumes passing off to a condenser (Fig. 2) and there condensed into about a 90 per cent nitric acid, which is collected in earthenware pots. As this strength would very soon corrode through the steel tanks, the acid is discharged in a tank partially filled with strong sulphuric acid. Strong sulphuric acid eats away lead and weak sulphuric acid eats away iron and steel. Strong nitric acid eats away iron and steel. The acids are finally removed to the mixed acid storage where sulphuric acid is added to make the mixed acid for nitration.

Other sources.

11. Nitrogen products are also obtained as a by-product from coke ovens. They may also be obtained from the nitrogen of the air in one of several ways.

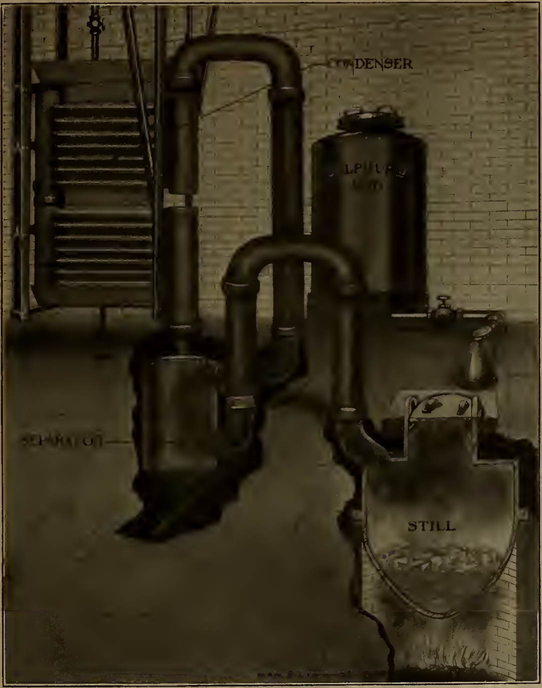


Fig. 2.—Nitric Acid Still.

In the cyanamide process, lime and powdered coke are burned in an electric oven, and calcium carbide obtained. This is nitrified in iron vessels into which is forced nitrogen made by distilling liquefied air, and cyanamide is formed from which ammonia is obtained by treating it with steam. In another method, the Haber process, nitrogen and hydrogen are combined directly under very high pressures. The hydrogen is obtained by injecting steam into a furnace containing red-hot coke, removing the CO_2 formed and leaving the hydrogen. The nitrogen is obtained by the distillation of liquefied air. In these methods, ammonia is obtained and nitric acid is made by oxidizing the ammonia. In the arc process nitrogen monoxide (NO) is obtained from the atmosphere directly by using very high temperatures which are obtained from an electric arc. Decomposition is prevented by very rapid cooling, and when the gas is finally cooled it becomes nitrogen dioxide (NO_2) and it is then converted into HNO_3 by passing it through water in absorbtion towers. During the World War, extraction of nitrogen from the air received a great impetus due to the fact that nitrogenous substances must be imported into this country.

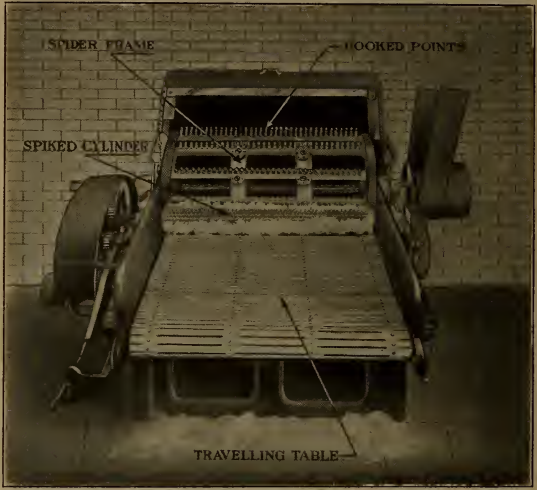


Fig. 3.—Cotton Picking Machine.

Manufacture of nitrocellulose. Cotton picking.

12. In the manufacture of nitrocellulose the first operation is the preparation of the cotton. The bales are broken open and the cotton is fed into a picking machine, which tears it out and fluffs it up. Sticks, knots, and foreign matter must be picked out. Different types of machines are used for long staple and short fiber cottons.

Cotton drying

13. The picking machine (Fig. 3) consists of a frame arranged with a traveling table on which the cotton is spread and fed to a small spiked cylinder. As it passes over this spiked cylinder a large spider frame covered with hooked points seizes the cotton and shreds it and then passes it out through an opening in the back of the machine into the drier room. Formerly the cotton was dried in bins in a house, the bins being so arranged that a free circulation of heated air was permitted. The present method is to use a continuous drying machine (Fig. 4). The cotton is passed along by a series of belts through an inclosed heated chamber and discharged at the opposite end. Steam coils supply the heat, and ventilating fans drive the heated air around the belts carrying the cotton. The cotton enters from the picker through a chute, dropping on a conveyor which discharges the cotton on a continuous belt passing through a heated chamber. Cotton in air will take up about 7 or 8 per cent moisture, and this must be reduced by regulating the time in the drier to about 0.5 per cent, as excess moisture will affect the nitration process.

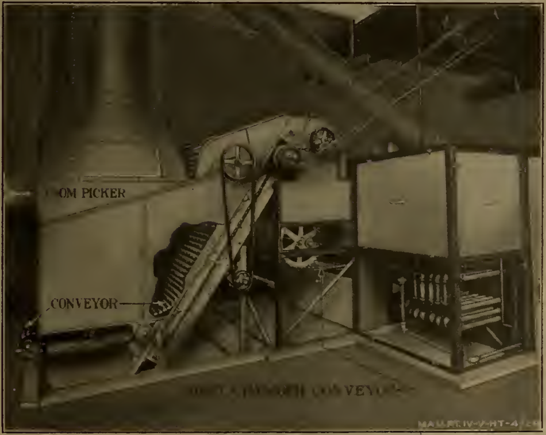


Fig. 4.—Cotton Dryer.

Nitration

14. Four different systems have been in use for the nitrating process—the pot process, the displacement system, the centrifugal process, and the Dupont mechanical dipper system. The first was the original method used and consisted in steeping the cotton in pots. In the displacement system shallow pans were used and water was run in displacing the acid after nitration. In the centrifugal process the cotton was nitrated in wringers, then wrung out and drowned in tubs of water. The objections to these systems were the fumes given off, the time required, and cost of production. The best and most used system in this country is the last—the mechanical dipper system developed by the Dupont Co. The following description applies to this system.

Dipper process.

15. A diagrammatic sketch of the nitrating house, Plate 1, shows three floors. The top floor has four nitrators in each unit, with a measuring tank and suitable pipes and valves for handling the acids. The second floor has the centrifugal wringer directly below the four outlets of the nitrators, and the lower floor has a flume through which the nitrated cotton is washed to the boiling tubs and also a fume pipe for carrying off the nitrous oxide fumes.

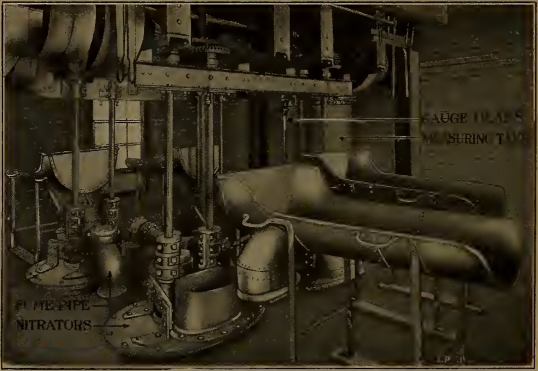
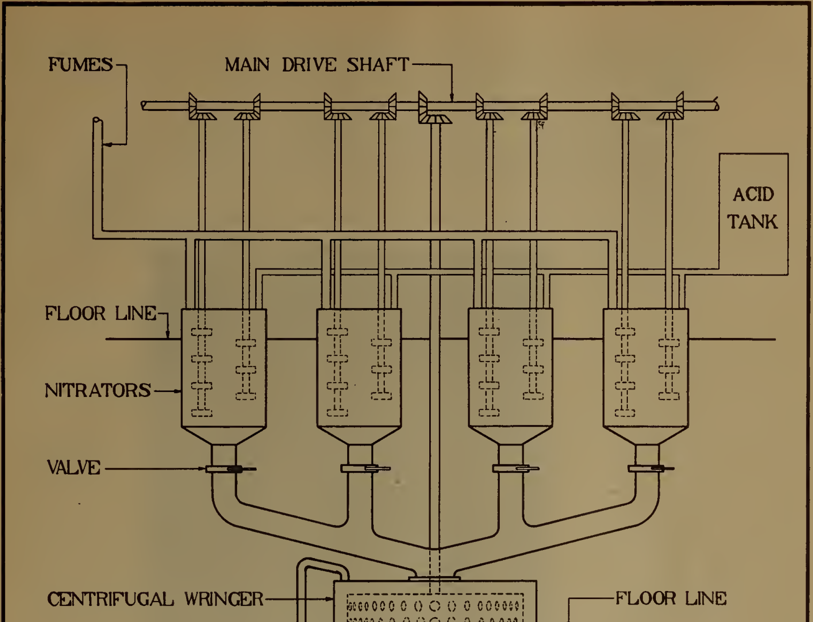


Fig. 5.—Cotton Nitraters (3rd Floor).

Operation.

16. In operating the mechanical dipper system about 30 pounds of cotton is placed in a nitrator and the proper amount of acid is run in, using the gauge glass on the acid measuring tank. The cover is placed on nitrator and the paddles are started at slow speed to keep the charge agitated and to prevent local deterioration and heating. The fumes pass out the fume pipe into the escape stack. The speed of the paddles is then varied according to the stage of the nitration, speeding up at first, then slowing down, and speeding up again at the end for discharging. The time for making soluble nitrocellulose is about 20 minutes. At the end of this time the drain is turned to discharge into the centrifugal wringer and the valve opened, allowing the charge to drop into the wringer. The wringer is then started, throwing the excess acid out against the sides, where it drains off to the spent acid tanks. The wringer, after five minutes in operation, is then stopped, the bottom



Diagramatic Arrangement of Nitrating Process.

removed, and the nitrocellulose pushed down into the receiver on the first floor. Water is admitted into the receiver at two diametrically opposite points, so diverted as to give a whirling motion, thus washing the nitrated cotton down the flume which leads to the boiling tubs. (See figs. 5, 6, and 7.)

17. The efficiency of this system can readily be seen, as one man, by continuous operation of a wringer, can keep pace with four nitrators.

Mixed acids.

18. The acids used are made by mixing sulphuric and nitric acids in the proper proportions. The nitric acid from the nitric acid plant has some sulphuric acid in it for safe transportation. More is added in order to give the proper percentages of each and also the proper acidity. These are called the mixed acids. After nitration, the acids discharged by the wringer are run off for salvaging for further use. They are called the spent acids. From an analysis of the spent acids it is determined how much nitric acid and sulphuric acid must be added to make mixed acids of the correct proportions. New or fortifying acids are used for this purpose. Thus a sort of cycle is made, the acids being used over again with the addition of sufficient to replace that taken out by the nitrated cotton. When it is desired to separate the spent acids for recovery, they are transported to the acid recovery plant, which is a part of the nitric acid plant. There the nitric acid is vaporized in contact with steam, condensed and recovered. The denitrated sulphuric acid is then bleached and delivered to storage tanks.

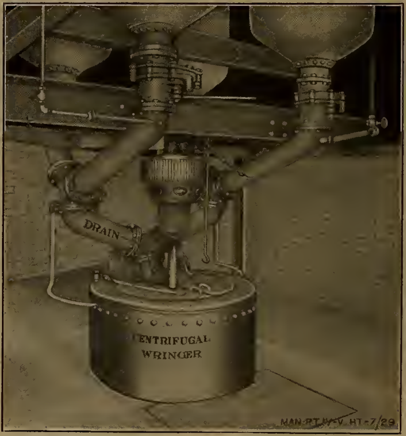


Fig. 6.—Nitrating House (2nd Floor).

Pyro purification.

19. The product is now a cellulose nitrate, usually called "pyrocellulose," or "pyro," containing an excess of acid, cellulose sulphates, and other impurities which may be detrimental to the stability of the final product. It is impossible to control the nitration process so that the product will contain a single nitrobody, but it is usually a mixture of nitrates of different percentages of nitrogen. Some are of the lower order of nitrocelluloses, which are not very stable, and these with the sulphates and other impurities must be removed to insure the final product having a uniform stability.

Drowning.

20. After nitrating, the pyro contains an excess of acid which would cause the material to "fire" in air, the cotton charring and giving off dense nitrous oxide fumes. For this reason it is necessary to "drown" the product in water. In the dipper system, this is done in the receiver or immersion basin, by the stream of water admitted for conveying the pyro to the tubs. By thus keeping the material in water, most of the free acid is allowed to pass off. In the pot and wringer systems of nitration, the pyro is quickly removed and dropped in tubs of water called drowning tubs. In the replacement system, where water is added, the excess acids are washed out and firing does not occur.

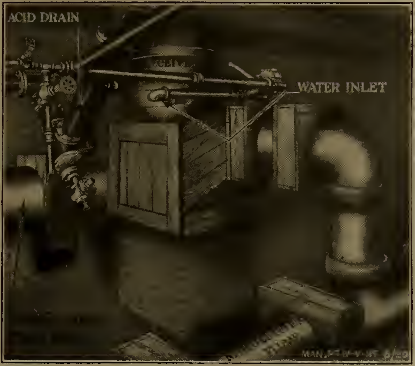


Fig. 7.—Pyro Discharge to Boiling Tubs (1st Floor).

Boiling.

21. The flume from the nitrating house (fig. 8) conducts the pyro by gravity to a double row of wooden tubs, each holding about 1,200 pounds of pyro, and by means of a system of gates may discharge into any one of them direct, thus providing cheap, safe, and effective transportation of the pyro. The tubs are of two types. One is fitted with a false bottom on which the pyro rests and beneath which a perforated steam pipe injects steam for supplying the heat for boiling.

Where the steam pipe enters it is entirely protected by wooden covers from the pyro, thus preventing the cotton from coming into contact with a hot pipe. Another and a later type is fitted with a percolator pipe so arranged that steam can not touch the pyro, but a circulation is given the contents of the tub. The pyro must be boiled for 40 hours to insure complete purification with at least four changes of water. It must be kept entirely covered during the process and the temperature of the water and ratio of steam to water such that actual boiling takes place.

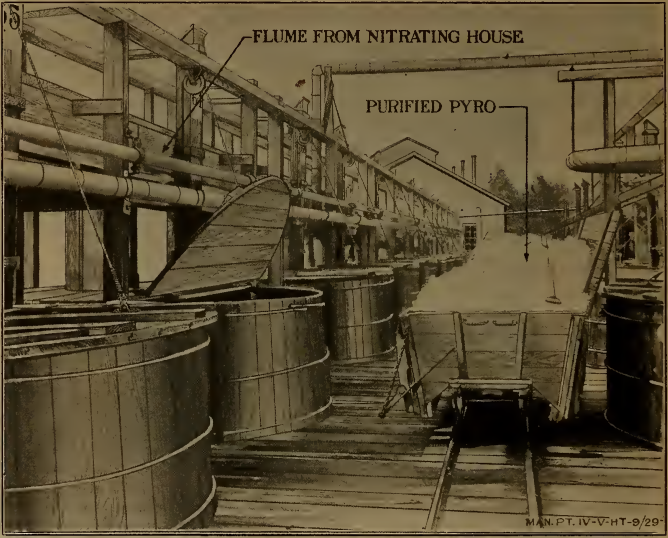


Fig. 8.—Boiling Tubs.

22. A tub is charged with the pyro, sufficient water run in to cover all the material, and steam turned on long enough to raise the temperature to 80°. The tub is then drained, refilled, and actually boiled for 16 hours. This operation is repeated three times with 8 hours actual boiling each time. On the conclusion of this treatment, the pyro is removed to a stuff chest in the pulping house for further treatment. It is most important that water of such purity be used that no additional impurities be introduced.

Pulping.

23. *Pulping.*—The treatment after nitration up to this point may be considered the preliminary purification, for only such excess acids and impurities have been removed which could be reached from the outside of the fiber. As the fiber is hollow, certain impurities are concealed within along with some low-order nitrocelluloses. To open up the fibers it is necessary to cut the pyro up in minute particles in order to allow the subsequent washing in the poachers to eliminate these final impurities. The development of this stage in the process is due to the efforts of Abel as a result of his work in determining the causes of the instability of guncotton as originally made. Two methods of pulping are used, one with a Miller duplex beater, similar to the one used in a paper mill, and the other with a Jordan pulping machine. The latter, being a continuous operating unit, is gradually replacing the beater, which is charged and operated for eight hours; then discharged in separate operations. A Jordan pulping machine consists of a rotating shaft fitted with sharp curved knives surrounded by a cone-shaped cylinder. The pyro is fed slowly in the large end, thrown out by centrifugal force, and gradually worked out the smaller end after digestion. It is customary to work these engines in multiple, the first giving a coarse cut and discharging into another which cuts to a finer degree, and so on until the pyro has been pulped to the required degree of fineness.

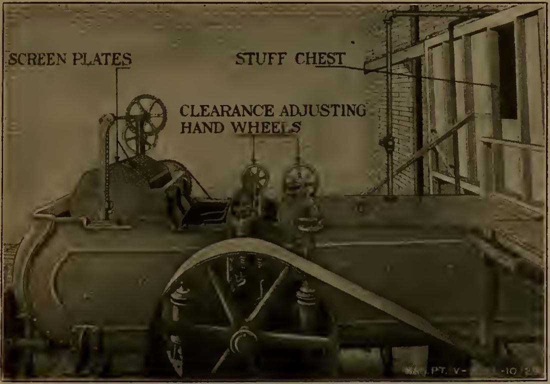


Fig. 9.—Duplex Beater, Pulping Machine.

24. The beater (fig. 9) consists of a long tank with a cast-iron revolving drum in a horizontal position in the middle, fitted with longitudinal knives. Directly above and below are curved plates covering an arc of about 20°, similarly fitted with knives. The drum is driven by a shaft projecting out of the side of the tank. The pyro is drawn from the stuff chest, dumped in gradually through the top, into **Beaters.**

the water which has been run in, and by the revolution of the revolving drum is circulated along the bottom under the knives and back across the top through the top knives. Handwheels are provided for adjusting the clearances. A frame carrying screen plates on each face with slits (*so small that the pyro can not go through, but the water can*) revolves in the mixture when lowered, and the water is entrained and drained off. The purpose of this is to remove excess water when it is changed. After about eight hours pulping, the pyro in suspension in water is pumped into large tubs called poachers (fig. 10). A treatment similar to the preliminary boiling is now given the pyro to remove the impurities brought out by the pulping. The dirty water is first drawn off and hot water is added and the charge boiled. It is necessary to have agitators in the poachers to keep the charge in circulation, due to the fineness of the pyro. Two other boilings are given, one of two hours and another of four hours, and then 10 cold-water washings. The pyro is then pumped through the screens (fig. 11) where all that is not fine enough is taken out and returned for further pulping and that which passes through is pumped to the dehydrating house, where each poacher charge is collected in a stuff chest and held for dehydration. The screen plates have narrow slits through which the pyro is drawn by suction, created by a diaphragm operated by a cam arrangement.

Poaching.

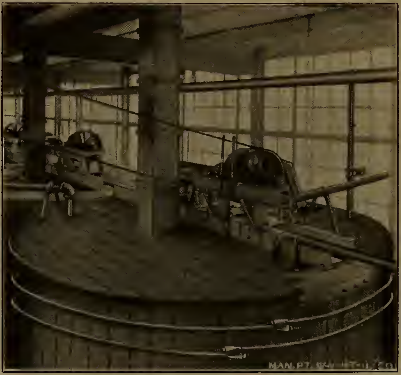


Fig. 10.—Poaching Tubs.

Dewatering.

25. The first step in dehydration is dewatering (fig. 12) where, by a vacuum system, a large part of the water is readily removed by being sucked into a cylinder through a canvas screen. The pyro is then wrung dry in the wringers shown in Figure 12. The water from the wringers is run into vats and allowed to settle, so

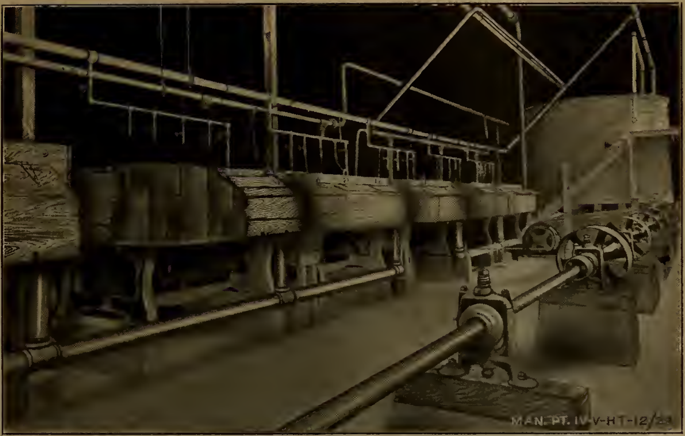


Fig. 11.—Pyro Screens.

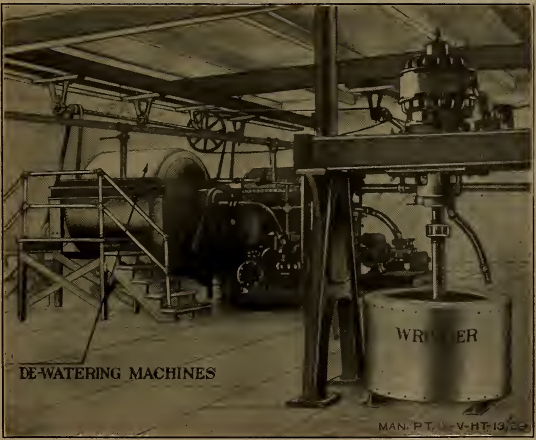


Fig. 12.—Dewatering Machine.

that the pyro thrown off by the wringers is thus saved. The final step in removing the water is performed in the dehydrating press (fig. 13).

26. A charge of pyro as it comes from the wringer is weighed out and placed in the cylinder of the press which is arranged with a top and bottom power piston, a pressure of about 300 pounds per square inch is put on it. This does not remove all the water, so that remaining is driven off by alcohol and at the same time the alcohol for the colloiding operation is added. The top is raised and the required amount of alcohol added from the measuring tank, and a pressure of about 3,000 pounds put on with air pressure. The alcohol is forced through the block and forces out the water ahead of it, the water draining off first, followed by weak alcohol, then strong alcohol. Sufficient alcohol is left in the block for the mixing operation. A finished block is shown in the plate. These blocks are of standard weight for the mixer, each containing a fixed weight of alcohol and the weight of pyro found necessary.

Dehydrating.

27. When the block is removed from the dehydrating press it is transferred to the mixing house, being first broken up in a "block breaker." The transportation is done in closed cans to prevent evaporation of the solvent. The mixing machine (fig. 14) is similar to a dough mixer. A charge is placed in the machine, the cover secured, and the revolving arms set in motion as the required amount of ether is added and the machine operated until thorough incorporation is obtained.

Mixing.

Diphenylamine.

28. The stabilizer is added at this stage of manufacture by mixing in the ether, before it is added to the mixer charge, sufficient diphenylamine to give about one-half of 1 per cent in the finished powder. It is added in this manner to allow for thorough incorporation in the colloid.

29. After a charge is thoroughly mixed, the mixer is tilted over and the charge dumped in cans and taken to the blocking press (fig. 15). This operation assists in the colloiding and provides a form for easy transportation. The blocks are transported in covered tins to the press house. In order to give a good incorporation and to eliminate lumps and foreign matter, the powder is passed through the macaroni press (fig. 16) and then reblocked in a press similar to the one in the mixer unit. The macaroni press has a diaphragm at the lower end of the press cylinder in which are bored a number of small holes. The powder is squeezed out through these holes in long threads, as shown in Figure 16, thus insuring thorough incorporation and a more uniform colloid. The block is then passed through the graining press (fig. 17), coming out as a long cord with the perforations made in it and is immediately passed through the grain cutter (figs. 18 and 19). The grains in the form shown in Figure 20 are removed to the solvent recovery for the removal and salvage of the excess solvent.

Pressing.

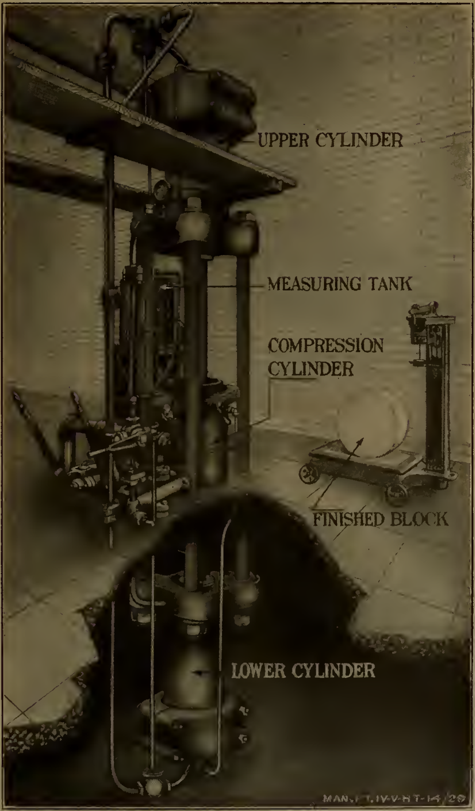


Fig. 13.—Dehydrating Press.

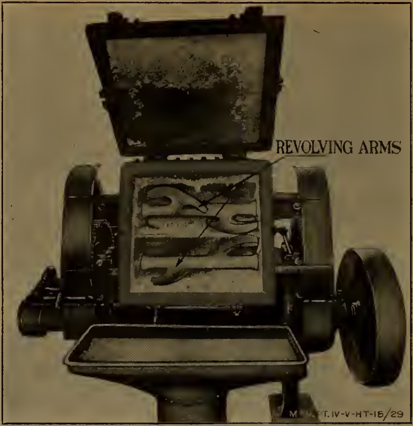


Fig. 14.—Mixing Machine.

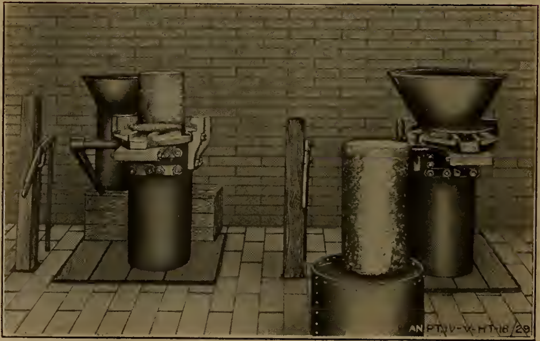


Fig. 15.—Blocking Press.

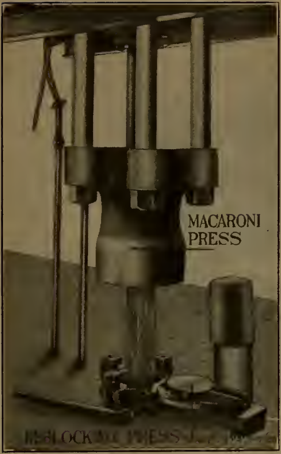


Fig. 16.—Macaroni Press.

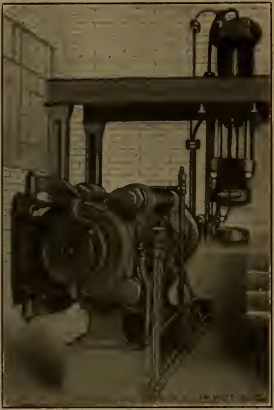


Fig. 17.—Graining Press.

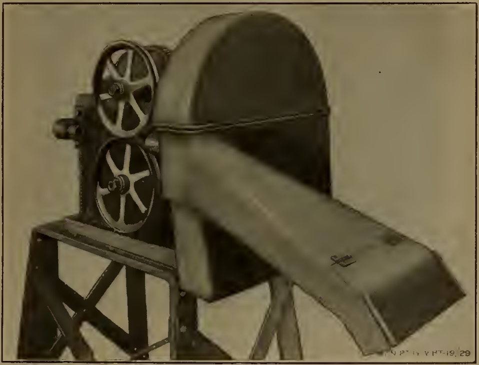


Fig. 18.—Grain Cutter (Cover in place).

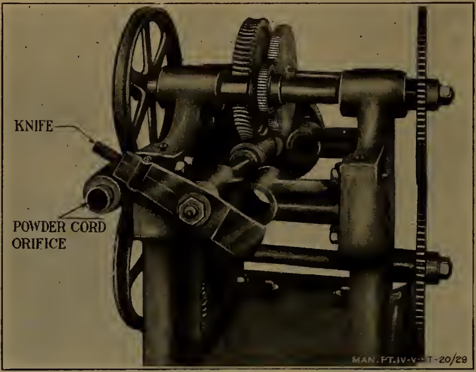


Fig. 19.—Grain Cutter (Cover removed).

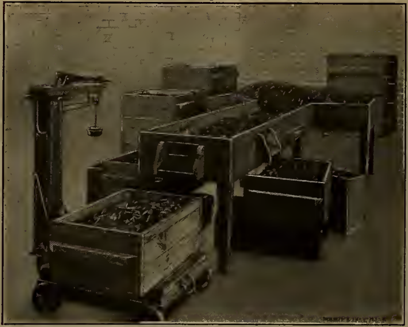


Fig. 20.—Sorting Table.

30. The perforations are obtained by the die (fig. 21) in the graining press. The powder while soft from the presence of solvents is forced by high pressure through a perforated plate which holds on the discharge side seven pins. The perforated plate fits on a cone-shaped face feeding into a hollow tube into which the pins project. As the powder is forced through the plate it surrounds the pins and is then squeezed down by the cone face and the inner walls of the tube to form a solid mass, which is forced out the end of the tube as a multiperforated cord. As the powder must have the proper amount of solvent to permit of this treatment and as this solvent must be removed afterwards by drying, thereby reducing the dimensions of the grain, it is a nice determination to fix upon the die dimensions in order to produce a definite final web thickness.

Powder dies.

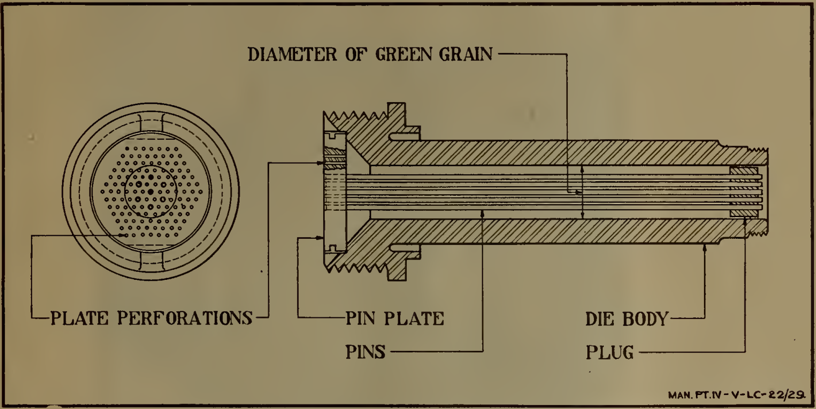


Fig. 21.—Powder Die for Multiperforated Grains.

31. The solvent recovery (fig. 22) consists of several vertical tanks in which the powder is dumped and through which air is circulated and cooled by a refrigeration system for the removal of the solvent by condensation. After the solvent is removed the air is reheated and passed through the powder again in a closed circuit. The heated air enters, passes through the charge and out the top, going to the cooling unit, where the solvent is recovered by condensation. The air then returns through the air-return pipe to the heater and is again forced through the system by the fan. The cans are charged from the floor above and discharged after treatment at the bottom. When the solvent has been reduced as low as is practicable for economic working, the powder still contains more solvent than is desired. That remaining is removed by exposing the powder to a temperature of from 45 to 55° C. in a dry

Solvent recovery.

Drying.

house (fig. 23). Each dry house is constructed with bins and has a hot-air system from an outside heating plant. The solvent as it is removed in this process is lost.

Blending. **32.** After drying the powder is removed to the blending tower and the lots are formed by blending in a gravity process (fig. 24). When the powder drops down the tower to the bottom floor it is packed in special smokeless-powder packing boxes for shipment (fig. 25).

Methods of drying. **33.** The most satisfactory method of drying powder is that given above, called the "air dry method." It has one disadvantage, namely, the length of time required. When rapid production is desired the water dry treatment is used. In this the powder from the solvent recovery, instead of being allowed to give up its solvents slowly by evaporation, is treated in large vats with warm water, thus rapidly removing the excess solvents. The powder is then given a very short period in the dry house or dried in a mechanical dryer. Another method, called the alcohol dry system, has been used. In this alcohol is the medium for removing the solvents instead of air or water. It has the advantage of removing the ether without loss.

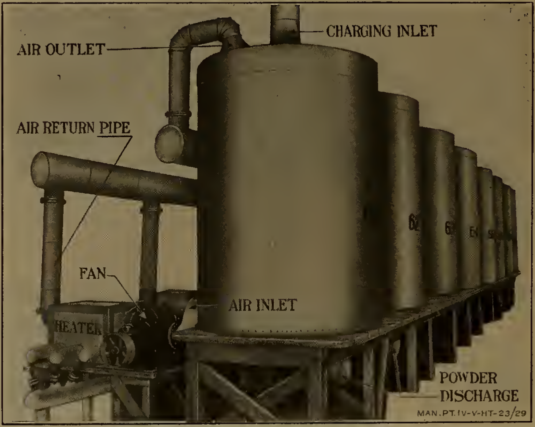


Fig. 22.—Solvent Recovery.

Burning of black powder. **34.** When a powder grain burns the combustion takes place on the surface and proceeds in parallel layers with a velocity dependent on the pressure and independent of the area of cross-section burning. In the open air the rate of burning is very low and the flame may be extinguished by blowing strongly on a lighted grain. When the powder is burned in an inclosed space, so that the gases resulting from combustion will produce a pressure, the rate of combustion is increased, but it nevertheless always proceeds in parallel layers. The action in burning is due to the physical structure of the powder. With an explosive mixture, such as black powder composed of various solid ingredients, even though finely divided and formed into grains under high pressure, will still have interstitial air spaces for the passage of inflammatory gases under pressure to all parts of the mass. The rate of burning of such a powder is under some control by the degree of pressing given or the size of the particles of the ingredients, but this treatment can not always insure a regular rate of burning.

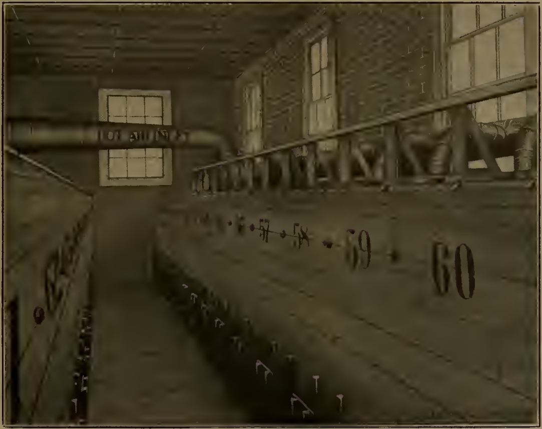


Fig. 23.—Typical Interior of Dry House.

Burning of smokeless powder.

35. Smokeless powder, on the other hand, is a homogeneous solid mass, as it is a "colloid" or "solid solution" of a single compound in a small amount of solvent. Inflammation can reach the interior of a grain only through the successive heating to the ignition point of layers of molecules by the burning of the layers outside of them. This progressive action can be seen by partially burning a grain in air and, after extinguishing the flame, by removing the film of partially affected material and finding the surface beneath unchanged by the presence of the flame. This same progressive action takes place in a gun except as to the rate of burning. The increased pressure causes a more intimate contact between the layer being consumed and that beneath undergoing chemical transformation. The ratio of the increase in speed of burning is estimated as from the one-half to two-thirds power of the pressure. The rate of combustion also depends on the composition of the powder as it is proportional to the temperature of the products of combustion. The higher the temperature of the burning gases the less time is required to bring successive layers to the ignition point. All Navy standard smokeless powder has the same composition within close limits, but this point will be referred to later.

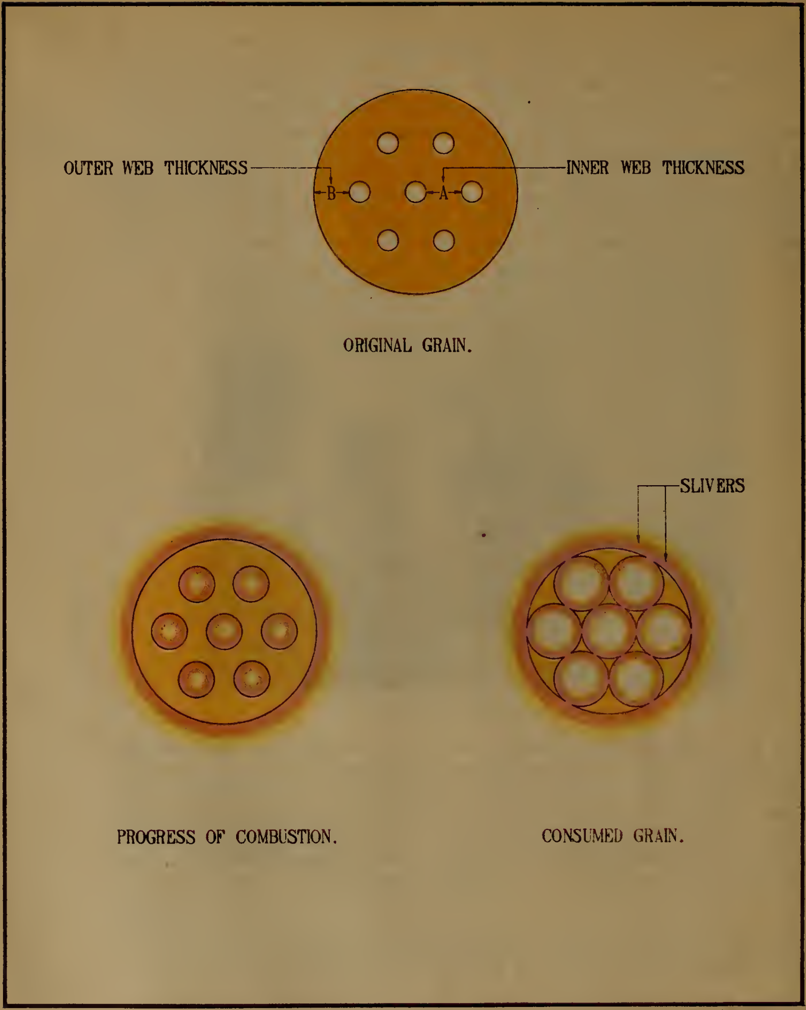
Progressive burning.

36. Before proceeding to the discussion of the form of a powder grain it is well to consider why it is necessary to have a powder which will burn progressively and why it is desirable to control its rate of combustion. When the powder charge burns in a gun a large quantity of highly heated gases is formed. For a given weight of powder the quantity of such gases by weight is constant and is equal to the weight of the powder charge, since all of the smokeless powder is converted into gas. Should this transformation take place before the projectile moves, the volume in which the gases are contained is that of the powder chamber, so that at the high temperature resulting the corresponding pressures are so high as to endanger the gun. This is what would occur were a charge of high explosive used such that the detonation would result in the explosive becoming gaseous in a very small increment of time. Were a high explosive used, a very small charge only could be employed to keep the pressures within reasonable limits, and the total amount of gases, and consequently the total energy available for translating the projectile, would be very low.

Fig. 24.—Blending Tower.

37. If, however, the projectile starts to move after a portion of the charge has been consumed, the volume the gases will fill is correspondingly enlarged and the

PLATE II.



Process of Combustion, Multiperforated Grain.

total quantity of gas may thus be made greater and consequently the total energy available is greater. This will permit of using a larger charge. What is desired, then, is that, as the projectile moves, the powder be consumed and continue to increase the quantity of gas as the volume to contain it is increased. It is necessary then to use such a powder that the projectile is in motion before the powder is entirely consumed, but that it is all consumed before the projectile has left the bore, as any further production of gases thereafter will be wasted.

38. In order to illustrate these points, attention is invited to Plate 2. In case of an instantaneous combustion the full pressure would be exerted on the base of the projectile before it began to move, and from maximum pressure "B" the gases would expand approximately adiabatically to the point of ejection "C." Should a powder be used which burns progressively the pressure would start approximately at "A" and increase to a maximum as the projectile moved, and then drop with the increase in volume after the consumption of the powder is complete. At first the pressure rises rapidly as the increase of pressure, due to combustion, exceeds its reduction due to the increased volume caused by the motion of the projectile. The ratio gradually changes until they balance at the point of maximum pressure and then the loss due to motion of the projectile exceeds the increase from combustion. When the powder has been completely burned, the gases will expand approximately adiabatically. The opposite extreme is found in using a powder which envolves gases at an increasing rate until the projectile moves out of the bore. Such a powder would be manifestly uneconomical and would bring the maximum pressure at the muzzle.

Fig. 25.—Packing Room.

39. If charges and the heat units are the same, the curves when produced infinitely will have the same area, so that at some point the curve for a progressive powder will run higher than that of an instantaneous powder. For the limited travel of a projectile, it is seen that at "C" the final pressure for a progressive powder is higher than that of an instantaneous powder, but that the maximum pressure of the latter is very much higher than that of the former. In Figure 26, curve "D" is for an instantaneous powder, curve "M" for a relatively "quick" powder, and curve "M′" for a slower powder, curve "E" would result from use of a very slow powder. It is to be noted that as the maximum pressure drops, the final pressure increases. Should a larger charge of the slowest powder be used, a great area would be included in the curve, but the final pressure would be raised considerably. In very slow powders the grains are not entirely consumed and a still greater loss in efficiency results. The time of burning is controlled by the nitration, the volatiles, the shape of the grain, and the web thickness; i. e., the thickness of the powder to be burned through to consumption. In Navy smokeless powders the nitration and shape of grain are kept constant, the volatiles restricted to narrow limits, the amounts depending on the size of the grain, and the speed varied by the size of the grain.

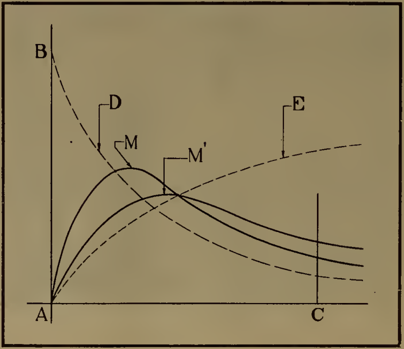


Fig. 26.—Combustion Pressure Curves.

Quick and slow powders.

40. Since the combustion of a grain of powder is entirely on the surface and proceeds in layers, other things being equal, the quantity of surface fixes the rate of gas evolution. Different forms of grains present different amounts of surface per unit volume, so that by varying the size and shape of grain as well as by variations in ingredients, great differences in speed of combustion may be obtained. For a given gun a powder is spoken of as "quick" or "slow," according to the rate of evolution of the gas. A small grain powder is quicker than a large grain powder, since all grains would be consumed in a shorter space of time if burning under the same pressure.

41. As new surfaces are constantly being developed during combustion, any shape of grain, which on burning presents new surfaces of greater extent, would have an increasing burning surface and evolve more volume of gas. A powder may be more or less progressive according to whether the amount of burning surface increases or decreases at successive instants of time. Shape of grains.

42. Powder grains may be made of solid geometrical forms, such as cylinders, cubes, flat grains, strips, etc., but these are the least progressive forms as the burning surfaces are continuously decreasing. They may be made of a single perforated cylinder and have practically a uniform burning surface; or they may be made in the shape of multiperforated cylinders and have an increasing burning surface up to the time the web is burned through, and then have a decreasing burning surface. Navy standard powders above 1-pounder are made into multiperforated cylinders of the form shown in Plate 2. The dotted lines show the original cross section of the grain, the full lines the remainder, when the progressive burning stops. The shaded portions are the "slivers." The distance "a" is called the inner web, and the distance "b" is called the outer web, and in the course of manufacture these are made as near alike as possible. Navy powders always have seven perforations, and the web thickness is $\frac{D-3d}{4}$, where "D" is the diameter of the grain and small "d" the diameter of the perforations. The length is about two and one-half times the outer diameter.

43. The above description applies to the manufacture of a single-base powder. Double-base powders. As previously seen, Nobel discovered that a propellant might be made of nitroglycerine and nitrocellulose. This is called a double-base powder, as two definite explosive substances are contained in it, the nitrocellulose being dissolved in the nitroglycerine. The resulting material is plastic and readily is formed into grains, which on drying present a compact mass. The toughness of a grain of double-base powder is dependent on the amount of nitroglycerine present. Nitrocellulose and nitroglycerine are both composed of hydrogen, nitrogen, carbon, and oxygen, and whether alone or together, the same gaseous products are formed, though of different proportions. It is possible to show theoretically the quantities of the gases produced by combustion. They are mainly carbon dioxide, carbon monoxide, nitrogen, hydrogen, methane, ammonia, water as steam, and oxides of nitrogen. The carbon combines with the oxygen to form CO_2 or CO, depending on the amount of oxygen present. If CO only is formed, a greater volume of gas results, weight for weight, than if CO_2 is formed, as 12 parts of carbon and 16 parts of oxygen give one volume of CO, while 12 parts of carbon and 32 parts of oxygen give one volume of CO_2. However, the heat given off in forming CO_2 is vastly greater than when CO is formed, so that the formation of each volume of gas, heated and expanded by its own reaction temperature, leaves a balance in favor of CO_2 as a work producer.

44. For this reason, as nitroglycerine has more than enough oxygen to allow all the carbon to form CO_2, and gives off free oxygen on combustion, it is to be expected that a high temperature of combustion results. Nitrocellulose has a deficiency of carbon such that more CO is formed than CO_2. By combining these two explosive mixtures, the deficiency of oxygen in one is made up by the excess in the other. Consequently a double-base powder gives, weight for weight, less gas volume than a single-base powder, but gives a much greater heat. Weight for weight, the double-base powders would then be the most efficient, or for equal performance, a smaller weight of nitroglycerine powder would do the work of a larger charge of nitrocellulose powder, if this were the only consideration. The effect of the temperature is very important, however, on the life of a gun, and this is one of the reasons a nitrocellulose powder is used by the Navy. The effect of heat is treated under "Erosion." The disadvantage in using nitrocellulose powders is that after combustion of the powder, the CO gas remaining is combustible and, having an affinity for oxygen, will burn to CO_2 when air reaches it. This results in muzzle flash and "flarebacks," which would endanger a gun crew were the gas-ejector system not used. Regarding the muzzle flash, however, even with nitroglycerine powders there is some in evidence, as the theoretical proportions of gases are not attained.

Stabilizers. Deterioration of nitrocellulose powders.

45. An important step was made toward a better quality of cellulose nitrates when the pulping process was introduced. However, the final purified product is subject to slight chemical changes with age and unfavorable conditions of storage which can not be prevented. It can, however, be slowed down and the stability life lengthened. By the definition of an explosive, the atoms can be regrouped into mores suitable compounds. The bonds holding the NO_2 radical in the smokeless-powder molecule are the weakest, and this radical is the first released. Its release, or the breakdown of the molecule, is accelerated by heat. Furthermore, the release of free nitrous oxide radicals causes a local heating tending to cause other and more stable molecules to give up their NO_2 radicals, and, in addition, their acid reaction also assists in further decomposition. Thus, the processes in deteriorating smokeless powder molecules are progressive and cumulative. As a result of this action, in older powders constant watching was required and frequent withdrawals from service of powders showing reduced stability became necessary.

Indicators.

46. During the early periods of use of nitrocellulose powders, no means were used for arresting the decomposition by incorporating other materials. It was found, however, that deterioration could be detected. This was accomplished by incorporating an organic dye which, due to the presence of free oxides of nitrogen, would change color; in other words, the powder itself would indicate deterioration. Rosaniline was the indicator generally used, giving the powder grains a reddish tint which, when affected by the acidity of the free oxides of nitrogen, gradually faded out. The rosaniline, although of primary value as an indicator, acted also in a slight degree as a stabilizer. Further study showed that if a substance could be incorporated in the powder which would take up the oxides of nitrogen as they were freed, the process of deterioration would be slowed down. Such a substance was found in diphenalymine. It actually combines with the NO_2 radicals, and in so doing undergoes a process of successive nitration, each molecule being able to take up any number of NO_2 radicals up to six.

Stabilizers.

47. Actually, on chemical examination of a smokeless powder, it is possible to detect a series of diphenylamine compounds containing different quantities of nitroradicals. Until the diphenylamine will take up no more the stability of the powder is unimpaired. Diphenylamine is now incorporated in all United States Navy smokeless powders and consequently prolongs their stability life. The change in chemical composition does not affect the ballistic qualities, as the new compounds form other gaseous compounds on combustion.

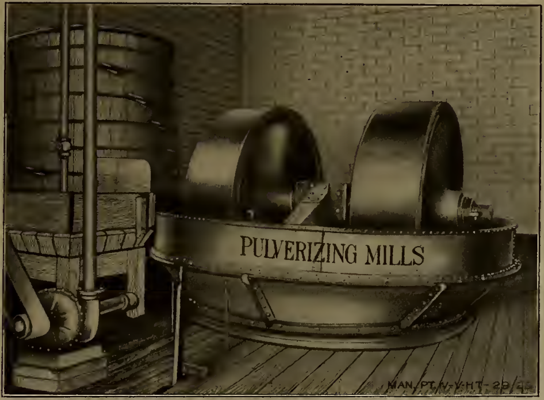


Fig. 27.—Rework Mill.

48. When the system of stabilizing smokeless powders was inaugurated, there was developed a system for reclaiming the unstable powders. This system of reclaiming or reworking powder has been extended to include remains of exhausted indexes, unstable powders, "fag ends" of lots too small for target-practice purposes, and powders dumped in water after target practice. Only straight nitrocellulose powders are reworked, as by this system only the cotton and acids can be reclaimed economically and efficiently. As a large percentage of the nitrated cotton is reclaimed, the product is not again treated with acids, so the percentage of nitrogen in the product as reworked must be that desired in the finished powder.

Reworked powder.

Operation.

49. The powder to be reworked is stowed under water in vats until required for use. It is then ground into a fine pulverized condition in water in steel-wheel mills (fig. 27). The charge is made by adding the powder grains in small amounts periodically and keeping up a continuous operation of the mill. The finely divided product floats off in the water and is deposited in a labyrinth after it has passed through a screen. It is collected and pumped into poachers, where it is given a special purification treatment similar to the poaching process for the new pyro. This treatment produces a reworked pyro, differing from new pyro in color and physical appearance. It requires special care in further manufacture and a different treatment is necessary throughout manufacture, especially in dehydrating and graining, though the processes conform in all major respects to that of new pyro subsequent to the poaching process. The final product is similar in appearance, however, to the finished powders made from new pyro, and the performance is in all respects satisfactory for the guns for which the reworked powders are designed and made.

50. Until a smokeless powder lot has been accepted, it is under a series of tests which may be grouped as chemical during manufacture and ballistic after manufacture. The raw materials are all tested to determine their suitability. The pyro is tested for purity and determination of nitrogen content. The acids are tested for composition, purity, and strength; the powder is tested for final composition and physical requirements, i. e., volatiles, stability, and size and uniformity of grains. After all these tests the powder must then be shown to be suitable for use in the gun for which designed, by giving an actual firing test the correct velocity within the allowed limits of weight of charge and pressure.

Test of materials.

51. Powder proof is generally conducted during proof of a new gun. The powder is heated to a standard temperature of 90° F., and is maintained evenly at this temperature until fired. With a new gun rounds from two lots are fired alternately, beginning with smaller charges and increasing the weight of charge above service. The velocities and pressures are taken on each round and plotted on cross-section paper to scale, with the velocities and pressures as ordinates and the weight of charge as abscissæ, and from the curves obtained the service and target practice weights of charge are picked off. Sufficient rounds are fired to demonstrate that the powder will give a regularity within one-half of 1 per cent at service.

Proof test.

52. When new guns are not available, the following method is followed. A standard powder of mean web and volatiles for each type of gun is selected and proved in three new guns under uniform conditions, for the selection of a master standard powder. This powder, which must show perfect regularity, is used as a standard for comparing other powders. A current standard is similarly selected and proved against the standard powder in an old or new gun. By comparing the results obtained, the correct charge for a new gun can be determined. The current standard is used in order not to exhaust the master standard too rapidly. When powders come to proof thereafter, they are proved in a new or worn gun against two rounds of the current standard, and the proper correction made for determining the ballistic properties with reference to the master standard. For instance, suppose A equals the correct weight of charge for the master standard under standard conditions, and under the same conditions the current standard requires B weight of charge; if, then, on some other day, a new powder gives C weight of charge to the current powders B′, then C should be corrected for the difference between B and B′, in order that the new powder may have a weight of charge which will give the correct velocity under standard conditions. All powders proved by this method will then give under similar conditions the same velocity for service weights of charge.

53. Frequent checking of the current standard and occasional checking of the master standard will show any changes in either.

Special propellants.

54. All Navy smokeless powders are manufactured as described above, with some slight differences due to difficulties experienced with varying grain sizes. A different treatment results in producing small-arms powders to obtain other compositions. The powder required must be quicker, hence it is of somewhat higher nitration, and also the grains are usually coated with some substance, ordinarily graphite.

Small-arms powders.

55. A special type of small-arms powder is used for blank cartridges, consisting of nitrocellulose and potassium and barium nitrate granulated in small round grains.

Ballistite.

56. A special propellant, called ballistite, is used for Stokes mortars. It is a double-base powder composed of about 60 per cent nitrocellulose and 40 per cent nitroglycerine, and it is made up into flake powder for loading into the paper shells. It is also used in shotgun ammunition.

Flashless powder.

57. The latest development in propellant powders is toward the production of a flashless powder. Its use is most desirable not only to mask the gun firing but also to relieve pointers and fire and ship control parties from the serious inconvenience of the blinding glare of the discharge of guns. The problem is to prevent the combustion of the incandescent gases of the powder on contact with the oxygen of the air. The problem is by no means a simple one as it means the addition of a substance, either to encompass the flaming gases or to reduce their temperature. Most of the substances thus far investigated act as deterrents, and thus affect the ballistics, and in addition produce an increase in smoke. Many substances have been tried, but the details are confidential. As one of the requirements is that the stability shall not in any way be reduced, the regulations regarding care and storage remain the same as for standard smokeless powder.

Chapter VI.

EXAMINATION AND TESTS OF POWDER ON BOARD SHIP.

Assignment to lots.

1. The details of manufacture of powder and explosives are discussed in Chapter 5. More detailed information regarding manufacture may be found by consulting works listed in the bibliography in the preface. Smokeless powder is a uniform ether-alcohol colloid of cellulose nitrates. Except for minor details the same specifications are used by the United States Army and Navy. The powder is manufactured in "lots" for the purposes of test and issue, varying in weight from 25,000 pounds to 125,000 pounds, depending on the granulation. After proof firing and acceptance, a lot or several lots blended together is given an index number and assigned to a specified gun with approved weights of charge for service and target-practice velocities. An index may be assigned to different calibers or marks of guns, in which case different weights of charge are assigned. Frequently, when projectiles having different weights, different band measurements, or when velocities differing from service are desired, other special weights of charge are assigned. In addition to the index number it is necessary to designate indexes by prefixing certain letters to show to which of the following classes a lot belongs.

Designation of lots; unstabilized.

(*a*) "*S. P.*" means "smokeless powder" and its use is held over from the time when indexes of both brown and smokeless powder were in service. At present, when used alone this prefix designates an "unstabilized powder."

Rosaniline.

(*b*) "*S. P. R.*"—Certain index numbers between 800 and 883 were manufactured with the addition of rosaniline as an indicator. These powders are reddish in color, and the indicator was intended to show by a change in color when the powder began to decompose. The rosaniline did not act in any way as a stabilizer, and like S. P. indexes, S. P. R. powders are classed as unstabilized.

Diphenylamine.

(*c*) "*S. P. D.*"—Following the use of rosaniline, the manufacture of powders containing diphenylamine was taken up. This chemical is a weak organic base and when incorporated in the powder serves to neutralize any acid products of decomposition at once and thereby prevents progressive deterioration of the powder, which is the ordinary effect of the acid products in unstabilized powders. All powders manufactured since index number 883 are stabilized by the addition of a small percentage of diphenylamine, and although some have been in service fourteen years, they are all of perfect stability, giving a surveillance test of 60 days plus, except in a few cases where they have been exposed to improper storage conditions. Unstabilized powders, on the other hand, have been and are continually being withdrawn from service for stability reasons. The prefix "S. P. D." denotes a stabilized powder.

Reworked.

(*d*) "*S. P. D. W.*"—The addition of the "W" denotes a "reworked powder." When indexes are declared exhausted and withdrawn from service, whether for stability, ballistic reasons, or "fag-ends" of lots, insufficient for use in target practice, or when dumped in water after use at target practice, the powder is shipped to the naval powder factory for "reworking." The powder is ground up, purified, and reprocessed as explained under the manufacture of powder in chapter 5, and reissued as new indexes. Reworked powders run slightly lower in nitration than powders manufactured from new pyrocellulose, and they are more brittle, but for regularity of ballistic results they are the equal of new powders in the guns to which they are assigned. It is the present practice not to manufacture reworked powder for guns of high service pressures, especially those of large caliber. Reworked powders are stabilized.

Water dried.

(*e*) "*S. P. D. X.*" indicates a stabilized water-dried powder. The requirements for rapid production due to the European War brought about the development of this process to a high degree of efficiency. All tests show that powders so manufactured are of excellent stability and regularity in ballistic qualities. The manufacture has not been carried beyond the 5-inch, 51-caliber powders so all powders of greater web thickness are air dried, but the possibilities can not be said to be exhausted.

Flashless.

(*f*) "*S. P. D. Q.*" denotes a flashless powder. By the addition of certain chemicals in a secret process the muzzle flash is reduced to a small red cone, practically invisible at any distance at night.

Blended lots.

(*g*) "*S. P. D. B.*" denotes a blend of more than one index, or lot to utilize "fag-ends" in target practice, for proof work at the proving ground, or to modify slightly the characteristics of the indexes forming the blend, such as blending a quick and slow powder to produce one of average characteristics, or to increase the amount of powder in the index.

Stability.

2. Smokeless powder, containing as it does the volatile substances, ether and alcohol, can not be held to possess unlimited chemical stability, and the length of its life depends very largely on the conditions under which it is stored. At temperatures approaching 100° F., the period during which it will retain stability sufficient to warrant its retention in service is relatively short. Although chemical tests give an indication as to the probable life of powder, no satisfactory method has been devised of foretelling with certainty its length of life. The only safeguard is, therefore, to discover loss of stability by frequent tests, and such tests shall be made with increasing care and vigilance.

Care in carrying tests.

3. Officers charged with the care of magazines and the examination and tests of smokeless powder shall thoroughly familiarize themselves with the practical methods of making such examination and tests, and shall be held responsible for the accuracy thereof and for the correctness of the official reports thereon. In order that the tests may be of value, as indicating the stability of powder, it is essential that the methods in all details shall be uniform, and those charged with this duty must follow strictly the prescribed methods. The apparatus and methods to be used are described in detail later on. Commanding officers may take advantage of visits to navy yards to send officers whose duties require supervision over powder tests to the ammunition depot in the vicinity for the purpose of obtaining special instruction in surveillance test work and for checking methods and results.

Record of tests.

4. The Bureau of Ordnance records all tests reported from the various sources and keeps careful records of the disposition and condition of each index, in order that proper steps may be taken, without delay, to dispose of any index which develops low stability. In the case of powder on the Asiatic station, including Samoa and Guam, this duty has been delegated to the inspector of ordnance in charge of the naval ammunition depot, Cavite. In order, therefore, that the system may be carried out, care is enjoined to submit correct and complete routine reports of ammunition on hand, stability tests, etc. More complete information regarding these reports is continued in chapter 23:

Prescribed tests.

5. The following examination and tests shall be made of smokeless powder on board ship:

(*a*) *Daily.*—Visual examination of samples and test for local heating in magazines. Examination of violet paper.

(*b*) *Fortnightly.*—Visual examination of each replacement sample.

(*c*) *Monthly.*—Visual examination of one or more charges of each index; 65.5° surveillance tests on samples from broken-down charges on all indices that give a test of less than 30 days.

(*d*) *Bimonthly.*—65.5° surveillance test from replacement samples on all indices giving 30 to 39 days' test.

(*e*) *Quarterly.*—65.5° surveillance test from replacement samples on all indices giving 40 to 59 days' test.

(*f*) *Semiannually.*—65.5° surveillance test from broken down charges, on all indices on board.

Magazine samples.

Replacement samples.

6. When ammunition containing smokeless powder is issued to a ship by an ammunition depot, there shall be supplied with each issue "magazine samples" contained in a glass bottle with a tight glass stopper, one for each index and magazine in which the index is to be stowed, and a "replacement sample" in an air-tight glass or metal container for use in bringing up to weight a charge which has been drawn on for surveillance test, one of the latter for each index issued. When ammunition is transferred, these samples shall accompany it. In case ammunition is expended, the magazine sample bottles and the replacement samples shall be returned to an ammunition depot. Ammunition depots keep on hand for observation small amounts of each index issued, these samples being known as "retained samples."

Stowage of magazine samples.

7. The different magazine samples shall be stored in the racks provided, in the same magazine with the indexes which they represent, and shall not be opened except for the purpose of changing the violet paper as provided for below. Magazine sample bottles shall not be used in surveillance ovens, nor shall "nonsol" bottles, especially prescribed for making surveillance tests, be usd for mgazine samples. Each magazine sample when received will have a strip of N/10 violet paper in it bearing a date showing when the test was started.

Daily examination.

8. The daily examination shall be made as part of the daily magazine inspection, which shall be made of all magazines and ammunition spaces, and shall consist of a visual examination of each magazine sample in a good light, without removing the stopper, to note whether the powder retains its normal appearance and for any change in the color of the violet paper. The presence, at any time, of reddish brown or orange colored fumes in the bottle will indicate decomposition of the powder. Since advanced decomposition of powder is often accompanied by heat, several charges of each index shall be examined daily for evidence of local heating by laying the bare hand on the surface. All charges being inclosed in metal containers, the heat emanating from decomposing powder is rapidly dissipated from the metal. While the hand is able to distinguish a few degrees difference in temperature between two containers' surfaces, it must be remembered that a large part of the charge must be in a very unstable condition to produce this heating effect. As many containers as can be readily reached should be observed in this way. Any charges which are apparently showing signs of heat from decomposition should be opened and the condition of the powder checked immediately by the other prescribed tests in order to insure a correct report of conditions.

Principle of violet-paper test.

8a. The result of the decomposition of nitrocellulose powder is the emanation of oxides of nitrogen, which, if not immediately absorbed by the stabilizers, will be given off in the form of gases. These gases are strongly acid and will attack materials like metal or cartridge-bag cloth. They also possess oxidizing properties, and this fact is taken advantage of in the violet-paper test, as the coloring material of the paper, methyl violet, is decolorized by the oxides of nitrogen. The strips of violet paper issued are of standard size and contain a definite amount of the coloring material. The paper strips when exposed to the gases given off by the decomposition of a standard sample of powder are attacked and will absorb a definite amount of oxides of nitrogen, and the coloring material in the paper will be changed from violet to white. The time required for this change in color is an indication of the relative rate of decomposition of the powder. For this reason, only one strip shall be exposed to a sample at one time.

Kinds of violet paper.

9. Two kinds of methyl violet paper are made for use in conducting test of smokeless powder. One, known as normal violet paper, has a deep tint and is used only in the laboratory for making the "German test at 135° C.," required by the powder specifications. The other is known as one-tenth (N/10) normal violet paper, and has a paler tint. The latter is issued to ships and ammunition depots for testing smokeless powder at normal atmospheric temperatures. The naval powder factory is the designated source of supply for violet paper, as it is prepared there in the laboratory, and shipped fresh as required. When received, the paper shall be transferred to tight glass-stoppered bottles and stored in a dark place. It is not affected by ordinary handling, but should be kept clean and dry, and it is used dry. It is not affected by other acids than oxides of nitrogen, and is only slightly affected by light, but it is better to subject all tests to as little light as possible. Deteriorating paper will show up by a whitening around the edges and when this occurs a fresh supply should be obtained. The Bureau of Ordnance supplies ammunition depots with their requirements on request, and as they always have a fresh supply in excess of their needs, ships may obtain new paper by applying direct to the ammunition depots. It is not considered desirable to have supply officers keep violet test paper on hand, as technical supervision is required to insure the use of a suitable quality.

Object of violet-paper test.

10. The object of the violet-paper test is to supplement the surveillance test and to give warning of powders requiring special vigilance. It can not be regarded as a definite quantitative test to the same extent as the surveillance test or the heat test conducted at ammunition depots. All indexes aboard ships shall be continuously subjected to violet-paper tests by means of the magazine samples, and ships not equipped with surveillance test ovens shall have three samples of all powders on board continuously subjected to this test, each representing a different charge. Doubtful powder should be given special attention on violet-paper tests.

Method of conducting violet-paper test.

11. To test powder from rounds, charges, or bulk powder, a sample of 12 ounces of the powder shall be placed in a 16-ounce glass-stoppered bottle. Fruit jars or 8-ounce bottles partly full will permit of carrying on a satisfactory test, as the quantity does not change the test, but it is better to have a standard procedure. ONE strip of DRY violet paper, marked in lead pencil with the date of starting the test, is dropped into the bottle on the powder and the bottle is then closed tightly. It is preferable to stow the bottle in the warmest part of the magazine, but as a rule special racks are provided. The bottle should be carefully protected from bright sunlight. The change in color due to the oxides of nitrogen, if any are present, causes a gradual fading to a faint violet, then a change to blue, and finally total loss of color, leaving a white paper. The time of the test is the number of days required for the paper to become white, and the bottle should not be opened during this time. In submitting reports of tests always show the total number of days from date on paper that the strip has been in the bottle, omitting the (+) sign to show that the paper has not turned white.

12. The paper will not become white in two months at ordinary temperatures. The same paper can remain in a sample bottle indefinitely, so long as it does not turn white. Cases have occurred where this test has run continuously for several years. If a noticeable change in color occurs in two months, another sample bottle should be started.

Influence of temperature.

13. As the decomposition of nitrocellulose powder depends to a very large degree on the temperatures to which the powder is subjected, so the duration of the violet-paper test is dependent on the temperatures existing during the test.

The violet-paper test of two months specified for serviceable powders above is intended as a minimum under the average temperature conditions obtaining aboard ship.

Comparison of surveillance and violet-paper tests.

14. The following table presents some useful comparisons between results of violet-paper test and surveillance test of the same powders.

Powder samples.	Surveillance test at 150° F., in days.	Violet paper.				
		At 64° F., in days.	At 70° F., in days.	At 100° F., in days.	At 110° F., in days.	At 150° F., in days.
6-pounder	7	217	67	12	3	2
Do	21	400+	252+	39	13	2
8/35-inch cal	19	81	21	5	2	2
Do	48	334	220	12	7	3

It might be supposed that it would be possible to use this paper in powder tanks or packing boxes, but such is not the case, because the oxides of nitrogen attack the cartridge-bag cloth and metal and increase the time of test so much as to make results unreliable.

Standard of color of violet paper.

15. The total loss of color of violet paper should be checked by examination in good light and comparison with prepared standards. These standards may be prepared by holding strips of the violet paper in red fumes formed by the action of dilute nitric acid on copper, or by exposing to the sun's rays a small quantity of small-caliber unstabilized powder in a bottle until a slight odor of nitrous fumes is noticed, and then dropping a strip of violet paper in the bottle, or by making use of one of the test samples in the surveillance oven when nitrous fumes first appear. Graduations of loss of color may be obtained in this way and the sample strips retained without special care for future use. Shipments of violet paper from the proving ground will contain sample strips (turned white) which have been exposed to nitrous fumes in the manner above described, and these strips may be used for purposes of comparison.

Fortnightly test.

16. Fortnightly, the powder in each replacement sample shall be visually examined for signs of decomposition or change in appearance. After making this examination, particular pains shall be taken to see that the replacement sample containers, the contents of which are to be exposed for as short a time as possible, are restored to their former air-tight condition. In event no replacement sample is furnished, one charge shall be used for this purpose and plainly marked as such.

Monthly test.

17. Monthly the powder in one or more charges of each index shall be visually examined for signs of decomposition or change in appearance and test samples removed for 65.5° surveillance test on all indices which gave a test of less than 30 days on the last surveillance test. Different charges shall be selected from time to time for this examination, and care shall be exercised to expose the charge for as short a time as will permit a thorough examination and to restore the tanks or cartridge cases to their former air-tight condition.

Nitrous fumes.

18. When a charge of powder decomposes, nitrous fumes are given off. These fumes have a pungent, characteristic odor which can be detected by smell when the package is first opened. To make this of value, it is necessary that the nostrils be applied to the charge immediately after opening the case, and that the officer making the examination be familiar with the odor of such nitrous-acid fumes. They must not be confused with the odor of ether or alcohol, which is natural, or with acetic-acid odors which are sometimes present in old ammunition. If decomposition has proceeded very far, the metal container may show signs of attack by formation of a green or white rust on the inside. Only in the very worst cases are there likely to be present orange-colored fumes of nitrous acid, and this would be accompanied by very strong corrosion of the case and an overpowering acid odor.

Visual examination.

19. The examination of powder for physical appearance should be made in a good light and by comparison with the magazine bottled sample. So long as the bottled sample maintains a reasonably good violet-paper test, this sample may be considered representative of the index. In examination of the charges the idea is to note a change from its original condition. Powder in service is of various colors, ranging from buff color to amber and black. Certain indices have been dyed rosaniline color, which in time may fade out, but this fading of color is not a cause for alarm, although indicating some loss of stability. It indicates the necessity for careful testing. Reliance may be placed on the violet-paper test and surveillance test. Stabilized powders may become black with only very slight decomposition, so that any darkening of the grain is not a criterion of its stability, as such a grain may be dead black and still have present 90 per cent of the stabilizer. Unstabilized powder becomes lighter in color as it decomposes.

Change in appearance.

20. When a grain of powder has considerably decomposed there is always set free nitrous acid which attacks the alcohol present in the grain and the tough qualities are in a measure lost. Fine hair-line cracks develop on the edge of the grain where there is the greatest loss of volatiles. Here the grain becomes brittle and the structure may be crumbled and broken off much like sugar, while the balance of the grain is still tough and hornlike. Finally the whole of the grain may be involved in this brittle condition. Grains which have developed even the first stages of such brittleness will show a very low violet-paper test and surveillance test, and such tests should be made to confirm the first diagnosis.

Surveillance tests.

21. As a further check on the stability of powder a surveillance test will be made on every index on board as follows:

(*a*) *Monthly.*—On all indexes which give a test of less than 30 days, sample from broken-down charge.

(*b*) *Bimonthly.*—On all indexes which give a test of from 30 to 39 days, inclusive, sample from replacement sample.

(*c*) *Quarterly.*—On all indexes which give a test of from 40 to 59 days, inclusive, sample from replacement sample.

(*d*) *Semiannually.*—On all indexes, samples from broken-down charges.

(*e*) *Special.*—To be made at such times as the officer responsible for the same considers necessary or proper, due to abnormal or unusual conditions, such as undue heating of magazines, etc. Wherever an index indicates loss of stability in the daily or fortnightly examinations or in the violet paper test it shall be subjected to the surveillance test at once.

(*f*) Small arms powder in rounds afloat need not be tested.

(*g*) Target practice or experimental firing ammunition afloat need not be broken down for surveillance test within six months of its issue from a naval ammunition depot, but thereafter ammunition of this type shall be tested the same as service ammunition, using powder from the magazine samples for the surveillance test.

Principle of test.

22. Any nitrocellulose powder will gradually decompose at high temperatures. For stabilized powders as the temperature increases above 90° F., the rate of decomposition rises rapidly. At ordinary atmospheric temperatures, however, such as are found in the magazines aboard ship, the rate of decomposition of serviceable powders is slow, and it is difficult to obtain quantitative data regarding the stability of a given powder at such temperatures, owing to the time required for the completion of a test. The violet paper test may be expected to show up a "bad" powder which is rapidly decomposing, but it can not be expected to give quantitative data regarding the stability and rate of decomposition of powders which are still serviceable.

Necessity for test.

23. This quantitative data is absolutely necessary for all powders afloat and ashore, not only for the protection of the ships, shore depots, and personnel concerned in their handling and storage, but also for the guidance of the Bureau of Ordnance in withdrawing powders from service when their stability begins to show progressive deterioration.

Results from test.

24. To obtain the necessary quantitative data regarding the stability of a given powder, advantage is taken of the fact that the rate of decomposition of smokeless powder is much greater at elevated temperatures than at normal atmospheric temperatures. The decomposition of the powder to be tested is "forced" by subjecting it to a constant artificial temperature of 65.5° C. (150° F.), and the time required by a standard sample of the powder to give off a standard visible amount of nitrous oxides (products of decomposition) noted. This test is known as the surveillance test, and the result expressed in "days" serves to give a definite measure of the stability of the powder. Successive surveillance tests show the rate of decomposition of the powder and form the basis of the data on which powders are condemned and withdrawn from service.

How made.

25. In the surveillance test a fixed quantity of the powder to be tested is inclosed in a special, tight, glass-stoppered bottle and exposed to a constant temperature of 65.5° C. in an electrically heated constant temperature surveillance oven supplied for the purpose to all battleships, cruisers, monitors, tenders, torpedo vessels, and to the large gunboats. The sample under test is examined once daily until red fumes appear, which mark the end of the test. The record to be made is the number of days it has taken to develop these fumes. The surveillance oven is described in chapter 7.

Reports of results.

26. The results of the surveillance test shall be reported to the Bureau of Ordnance on the smokeless powder test card (Ord. Form No. 67 and 67A, see ch. 23). At the end of 60 days the test shall be discontinued, unless for particular reasons it is desirable to run it longer, and any index which does not give red fumes within this period is to be reported as "60 days +."

Danger point.

27. On board ship when a powder gives a surveillance test of or below the limits given in the following table, a special report shall be made to the Bureau of Ordnance immediately and three samples shall be immediately forwarded to the nearest naval ammunition depot with a notation of the circumstances; the naval ammunition depot receiving the samples shall immediately make surveillance and heat tests and shall report the results of each as soon as completed.

	Days.
16″, 14″, and 12″/50	23
12″/45 and 10″/40	21
12″/40 and 8″/45	19
13″/35, 12″/35, and 7″/45	18
10″/30, 8″/35, 6″/50, 5″/51, 4″/50, Mark IX	17
6″/40, 5″/50, 4.7″, and 4″/50, Mark VIII	16
All others	15

Action to be taken when below danger point.

28. Smokeless powder indexes or parts thereof at naval ammunition depots giving less than two-thirds the limits fixed in this table, will be segregated pending instruction from the Bureau of Ordnance regarding their disposition.

Surveillance test bottles.

29. In making a surveillance test, the number of 8-ounce, salt-mouth, "nonsol" glass-stoppered bottles required are thoroughly washed and dried. The particular type of bottle which must be used is supplied from the naval powder factory, Indian Head. It has a peculiar, pale, yellowish-green color which makes it readily distinguishable from any other glass bottle known. This type of bottle shall not be used for violet-paper tests. The bureau obtains its supply from the Whitall-Tatum Co., of Millville, N. J. The stoppers are of ordinary glass, ground in with fine emery and a solution of camphor and turpentine to make an air-tight joint, after which the stopper and bottle must be thoroughly washed. When a stopper has been ground in to fit a bottle, it should be attached to it loosely with a piece of twine, but the twine must not be used to tie the stopper down during a test. Sealing wax shall not be used to seal bottles during a test. Each bottle has an etched space on it which serves for pencil markings showing the index number and date of commencing and ending the test.

Selection of samples.

30. Powder from any sample or charge may be used if so desired by the gunnery officer, but surveillance tests of powder samples taken as set forth above for the monthly, bimonthly, quarterly, and semiannual tests must be conducted.

The powder shall be exposed to the air as short a time as possible. Five whole grains are to be used for large grained powders, such as 10″/40 and above, except the 13″/35 and 12″/35; 45 grams in whole grains shall be used for powders for guns below the 10″/40, including the 13″/35 and 12″/35. The proper entries shall be made on the etched space of each bottle. The bottles, after the stoppers are fitted snugly, are placed in the surveillance oven, and if all the spaces are not filled empty stoppered bottles will be used to fill the oven in order that a more reliable heat distribution may result. It is most desirable that the room in which the surveillance oven is placed be maintained at as constant a temperature as can possibly be obtained. As the test continues the temperatures within the oven shall be maintained at 65.5° C. ± 1° C. The automatic relay will ordinarily provide this careful regulation, but should this in any case fail to function the test will be vitiated, either by allowing the oven to cool off or by overheating. Frequently explosions occur in the ovens, due to overheating from a failure of the relay to cut out the necessary heating units. It must be borne in mind that under the influence of the heat applied the molecules of nitrocellulose break down and the nitrous oxide radicals are released. The greater the heat applied the shorter the time to this breakdown. If any doubt exists as to the reliability of the relay, the oven should be watched. As it is impossible to predict just when the nitrous oxide fumes will appear, each bottle containing a sample shall be examined daily for the appearance of the characteristic red fumes. The examination will consist of holding the bottle in a good light against a white paper background, with the "fume tube" alongside for comparison. A "fume tube" is provided for each oven filled with nitrous oxides prepared at the naval powder factory, according to the fixed standards. The bottles must not be opened while the test is in progress, but shall be expeditiously removed from the oven, examined, and quickly replaced, and precautions shall be taken to retain the heat in the oven. The control thermometer should be frequently checked.

Method of conducting test.

Completion of test.

31. When the red fumes appear in a bottle the test is completed, and a record is made of the number of days which have elapsed since the test was started, this being the measure of the stability of the powder. Should there by any doubt as to the presence of fumes at a daily examination, the appearance should be carefully noted and a close examination made on the following day, when the additional 24 hours' exposure should have considerably increased the depth of color. The standard fume tube should always be used for comparison. When unmistakable signs of red fumes have appeared, or when the test has run for 60 days, the bottle shall be promptly removed from the oven and the sample thrown overboard. After a test the bottles are thoroughly washed and dried and another test started, or else they are reserved for future use. With small-caliber powders not in good condition, the fumes develop quite rapidly, and the powder might explode if the test is carried too far. This is due to the fact that the rate of decomposition is increased by the presence of the oxide fumes, but no case of this sort has occurred with large-caliber powders, where the proper temperature has been maintained constantly.

Care in carrying out tests.

32. It is most essential, to have the results obtained be of any value, that the strictest care be paid to complying with the instructions for carrying out the surveillance test. If conditions are constant, the results obtained are practically duplicated on tests at different times, unless some change has taken place in the powder sample. An increase in moisture content, or decrease in solvent content of a powder, or actual decomposition in the powder will all affect results by reducing the time of test.

Procedure if no oven is available.

33. If no surveillance oven is furnished, or if for any reason the one on board is not available for use, the prescribed tests should be made at an ammunition depot or aboard another vessel. The responsibility for carrying out the prescribed tests rests with the commanding officer and he is empowered to arrange for having these tests conducted as called for above, the arrangements to be made without reference to the Bureau of Ordnance, except, when on detached duty, information regarding the most suitable place or ship to which samples may be forwarded may readily be obtained from the bureau. Vessels of the Navy and ammunition depots will conduct tests for Coast Guard vessels or stations in the same manner as for naval vessels. For the manner of handling reports of tests conducted on another ship or at an ammunition depot, see chapter 23. In case it becomes necessary to ship a sample by transport or rail (shipments by mail are absolutely forbidden) the instructions regarding such shipments contained in circulars issued by the Bureau of Explosives, of the Interstate Commerce Commission, should be consulted. The test sample, suitably marked, shall be placed in a clean, glass, air-tight bottle, sealed with paraffin or wax, and the stopper secured by a cloth covering and twine seizing. A test sample shall consist of four ounces. Samples shall be properly packed and boxed to minimize breakage during transportation.

Transportation regulations for explosives.

34. The following abstracts from the Interstate Commerce Commission regulations for "The Safe Transportation of Explosives and Other Dangerous Articles by Express" are quoted as applicable to shipments of smokeless powder samples.

Smokeless powder; how shipped.

1. The only samples of explosives that can lawfully be shipped by express are those intended for examination in a laboratory.

Quantities.

2. (*a*) Samples of explosives for laboratory examination when properly packed and not exceeding a net weight of one-half pound for each sample, and not exceeding 20 such samples at one time in a single vessel or vehicle.

The following explosives may be accepted for transportation by express, when offered in compliance with these regulations:

(*b*) Small-arm ammunition.
(*c*) Small-arm primers.
(*d*) Cannon primers.
(*e*) Percussion fuses, including tracer fuses.
(*f*) Time or combination fuses.
(*g*) Safety fuse.
(*h*) Safety squibs.
(*i*) Common fireworks and special fireworks, except when forbidden.

Packing.

3. Samples of explosives for laboratory examination must be placed in well-secured metal cans or glass bottles or in strong waterproof paper or cardboard packages containing not more than one-half

pound each, and the interior package must be placed in dry sawdust or similar cushioning material in a strong and tight wooden box, with ends not less than 1 inch thick, and top, bottom, and sides not less than one-half inch thick when a nailed box is used, or with ends, top, bottom, and sides not less than ½-inch thick when of lock-cornered construction.

Weight. 4. Not more than 20 half-pound samples of explosives for laboratory examination may be placed in one outside box or transported at one time.

Marking. 5. Each outside package containing samples of explosives for laboratory examination must have securely and conspicuously attached to it a square red certificate label measuring 4 inches on each side and bearing in black letters the following:

Red Label for Samples of Explosives

(Reduced Size)

EXPLOSIVE

Sample for Laboratory
Examination

Handle Carefully
Keep Fire Away

This is to certify that the above articles are properly described by name and are packed and marked and are in a proper condition for transportation, according to the regulations prescribed by the Interstate Commerce Commission.

. . . .
(Shipper's name.)

Resealing containers. **35.** Containers which have been opened for examination of contents or for the removal of powders for test are to be restored to their former air-tight condition. Cartridge cases will have projectiles or mouth plugs replaced and will be made air-tight as follows: With fixed case ammunition the joint between the end of the cartridge case and the rotating band of the projectile shall be covered with adhesive tape and given a coat of clear shellac; with separate case ammunition closed with a cork mouth plug, the plug will be shellacked on the side and replaced and the outer joint then coated with shellac. In the event the mouth plug is damaged, so as to render it nonair-tight, the mouth of the cartridge case will be covered with clean canvas and seized with twine, after which a coating of clear shellac will be given the entire end.

Powder not to be destroyed. **36.** Powder shall not be destroyed unless it shows unmistakable signs of advanced decomposition. In the event of such deterioration, every charge of the index on board shall be examined, and only such charges will be destroyed as contain the decomposing powder. Decomposition in the sense here used is evidenced by—

(*a*) The grains being friable and easily crumbled;
(*b*) Unmistakable odor of nitrous fumes; and
(*c*) Very low violet paper and surveillance tests.

Powder found in a soft or mushy condition will be thrown overboard immediately. However, occasion should arise only under the most unusual circumstances requiring such action, as frequent and constant observation and strict compliance with these instructions for powder tests will show loss of stability long before a powder becomes decomposed. In case it should be necessary to destroy or land smokeless powder for loss of stability, samples of each index shall always be preserved and forwarded to the naval powder factory, Indianhead, Md., for examination, and the Bureau of Ordnance notified at once of the shipment and the reasons therefor.

Ballistic errors of powder.

37. The foregoing has dealt almost altogether with matters relating to the care, preservation, and stability of smokeless powder. The effect of various conditions on the ballistics of powder is covered in chapter 20, and "Gunnery Instructions, 1920," chapter 22, both of which should be studied by all officers concerned. A considerable number of the factors mentioned in these publications as affecting ballistics are outside of the control of the ship, but attention is especially invited to the following:

(*a*) Exposure to moisture during storage will increase the volatile content, make the powder "slower" and lower the muzzle velocity for a given weight of charge.

(*b*) Exposure to high heat during storage, in nonair-tight containers, will decrease the volatile content, make the powder "quicker" and increase the muzzle velocity for a given weight of charge.

(*c*) Under certain conditions exposure to the atmosphere may produce both conditions (*a*) and (*b*) above, which may tend to neutralize each other, but unless all powder charges are subjected to the same treatment, will cause great irregularity in muzzle velocity. Thus, it is necessary for uniform ballistics as for stability that powders be kept in absolutely air-tight containers and not subjected to high temperatures. "The importance of keeping powder charges air-tight is to be considered on a par with that of keeping the sights in condition." Loss of stability, unless it has gone so far as to render powder unserviceable, will not appreciably affect ballistics if other conditions are normal.

Salvage of ammunition.

38. In case of shipwreck, flooding of magazines, or other casualty whereby ammunition is wet or damaged, steps should be taken by the officers in charge to forward the damaged ammunition to an ammunition depot for salvage as soon as practicable. In no case should such damaged ammunition be thrown overboard or abandoned if it can be recovered, and every reasonable care should be taken in handling to avoid damage to containers. If shipment is materially delayed for any cause, smokeless powder which has been wet should be shipped completely immersed in distilled water. The ammunition so treated shall always be suitably marked to show its condition, and the complete history forwarded to the bureau so that intelligent action may be taken regarding the disposition. The Government has suffered material loss in the past due to the failure of officers to carry out these instructions.

Chapter VII.

SURVEILLANCE OVENS.

1. The Washington Navy Yard is designated as the central source of supply for all types of surveillance ovens, and all ovens to be furnished ships and stations will be supplied from that yard. Spare parts for all types of surveillance ovens will be kept in store at the Washington Navy Yard. The proving ground is the source of supply for bottles and fume tubes. The Washington Navy Yard will make out ships' allowance lists for all surveillance ovens, including spare parts. Surveillance ovens will be assigned serial numbers by the Washington Navy Yard, and a record of their disposition will be kept on file there. All surveys of surveillance ovens and all requisitions for parts of ovens should, in every case, give full information as to the make (or mark), number, voltage, etc., of the oven affected by the survey or requisition. When a surveillance oven has been damaged so that the estimated cost of repairs exceeds 50 per cent of its invoice value it shall be transferred to the navy yard, Washington, D. C., and a new oven requested. **Source of supply.**

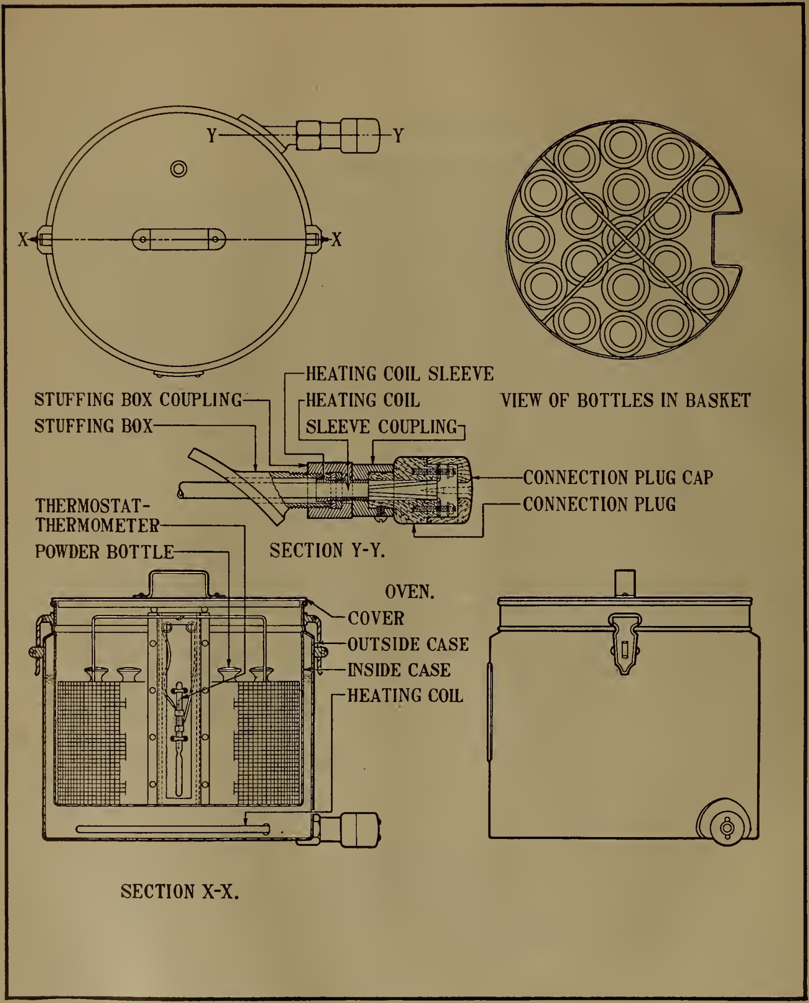
2. The purpose of these ovens is to conduct the surveillance test of smokeless powder described in chapter 6. This test consists in the determination of the time which smokeless powder requires under the prescribed standard conditions of the test to produce visible red oxides of nitrogen. The standard conditions and methods of conducting the test are fully described in the previous chapter. The surveillance oven is designed to maintain a constant temperature of 65.5° C. (±1° C.). **Purpose.**

3. The Mark I and Mark I Mod. 1 ovens were designed to operate on a 125-volt and an 80-volt circuit, respectively. These ovens have been declared obsolete and are no longer manufactured or repaired. All are being replaced as they become unserviceable by the later designs of the Mark II ovens. The description of these ovens is included in this manual for reference in case the few remaining in service are required for use. **Mark I and Mark I Mod. 1.**

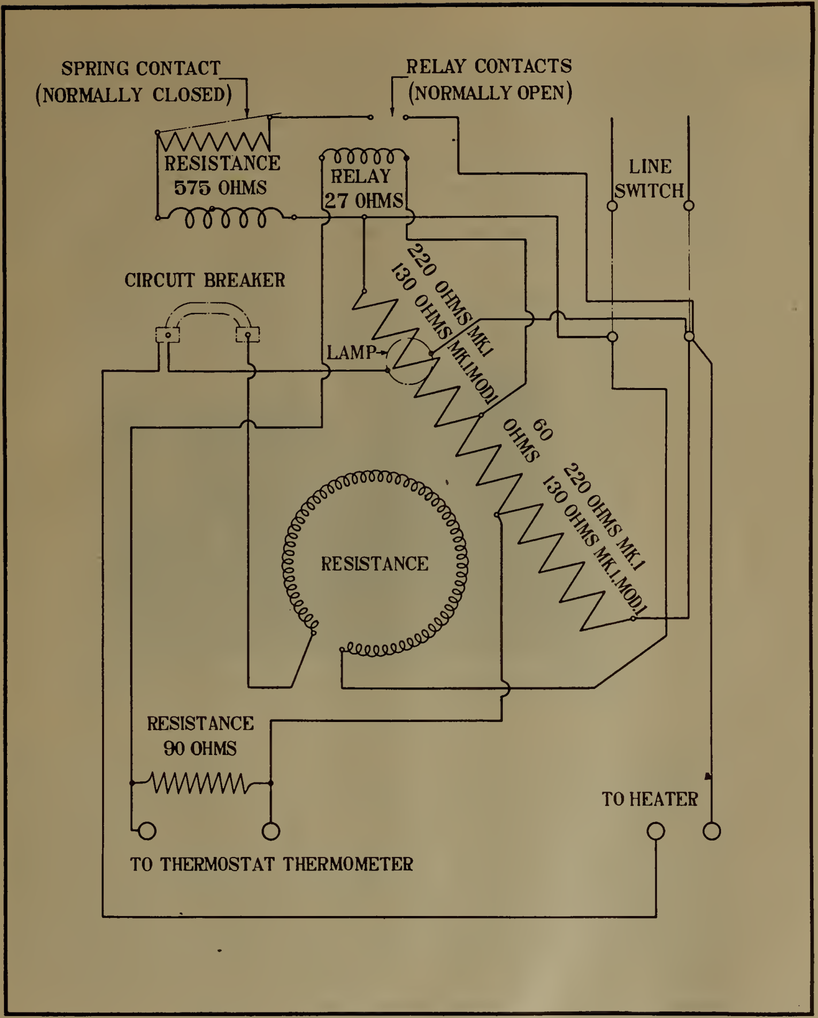
4. Each of the Mark I and Mark I Mod. 1 surveillance test ovens consists of the following principal parts:

(*a*) Double-walled copper oven with cover.
(*b*) Heating element.
(*c*) Special mercurial-control thermometer.
(*d*) Mercurial centigrade stem thermometer.
(*e*) Eighteen 8-ounce salt-mouth "nonsol" glass bottles.
(*f*) Wire basket to accommodate glass bottles.
(*g*) Electrical controlling panel.

PLATE III.



Surveillance Oven, Mark I, Model 1. General Arrangement.



Surveillance Oven, Mark I, Mod. 1. Wiring Diagram.

Description of Mark I.

5. The copper oven is circular in shape and made in two sections, and so constructed that one section is snugly suspended in the other. The inner section is 12 inches in diameter, and, excluding cover, is about 10 inches high, while the outer section is 13 inches in diameter and about 10¼ inches high. When the two sections and the cover are in place the approximate overall dimensions are about 13 by 18 inches, the latter dimension including the extension of the connecting plug for the heater. The inner section is provided with a cover made of copper and lined on the inside with a heat-insulating material to a thickness of about $\frac{5}{16}$ of an inch. This cover is provided with a strong handle on its top, and also contains a hole for the insertion of a 12-inch centigrade stem thermometer. The inside of the inner casing of the oven is provided with a rectangular pocket for the support of a mercurial-control thermometer, and two holes are provided near the top of the oven just above this pocket, through which the wiring from the control panel to the mercurial-control thermometer is passed. All joints in the copper oven are brazed. A name plate giving the mark and modification numbers of the oven and the voltage of the heating element is riveted to the outer case of the copper oven. Two hinged hasps with staples, one on each side, are riveted near the top of the oven and serve to firmly hold the two sections together. When in service, the outer copper casing is partially filled with a quantity of glycerin (about 5 quarts), which, when the inner casing is in place, rises to a height of about 6 inches above the bottom. The glycerin serves to conduct the heat from the heating element to the inner copper casing in which a wire basket containing the powder samples is placed.

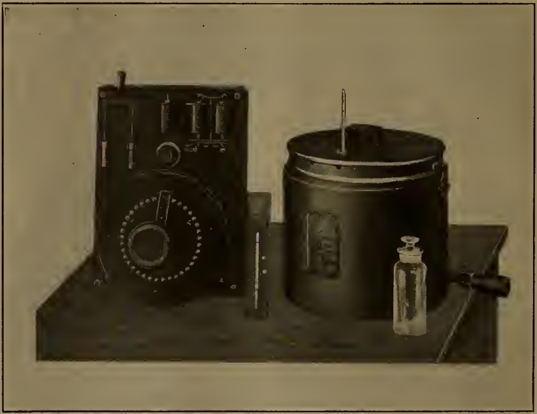


Fig. 28. Mark I. Oven Assembled.

Heating element.

6. The construction of the heating elements now in service varies to a small degree, in that the number of turns of the tubing varies from 1½ to 4, and that the two heating wires in some coils are of equal diameters and installed parallel in the tubing, while in others one wire is considerably larger than the other, and these wires are installed in the tubing in such manner that the small wire is wound over the larger. However, the heating elements all consist of a ⅜-inch special tubing, which, in most cases, is approximately 75 inches in length, into which is embedded two asbestos insulated resistance wires of a size and length to consume nearly 300 watts. The tubing is wound in spiral form to an outside diameter of 10 inches, and so that the coils of the tubing all lie in a horizontal plane. The free or inner end of the coil is permanently sealed, while the outer end is fitted with a small threaded nipple which provides for the support of a hardwood plug that facilitates connection from the heating wire to the "heater" circuit on the control panel. This threaded nipple, in conjunction with a brass lock nut coupling and a special nipple riveted and soldered at the side and bottom of the copper oven, also forms a support for the outer end of the heating coil. The special nipple referred to above is provided with a left-hand thread. Between the face of the brass lock nut, which screws on the end of the heating element, and that of the special nipple a rubber gasket is provided to insure a tight joint and prevent leakage of the glycerin solution through the place where the end of the heating coil projects

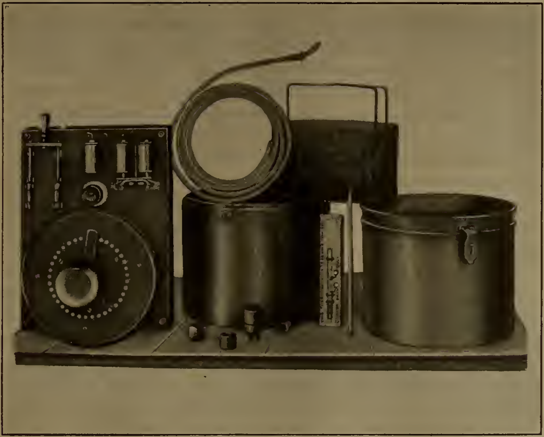


Fig. 29.—Mark I. Oven Disassembled.

through the outer casing of the oven. The heating element is located in the space between the bottoms of the inner and outer sections of the oven, but lies very close to the bottom of the outer casing. The 80-volt elements are rated at 3.5 amperes and those for 125-volt circuits are rated at 2.8 amperes. To install a heating coil, the two screws are removed from the end of the wooden connecting plug, the cover of the plug removed, the resistance wire disconnected from the two binding posts, the remainder of the wood connecting plug removed, and the coupling and brass lock nut removed. The inner section of the oven is then removed, the coil placed in the outer section, and the outer end of this coil passed through the special nipple from the inside; the rubber gasket is then put in place, the brass lock nut screwed on tight, the coupling firmly screwed in place on the special nipple, the bottom half of the connecting plug screwed on, the connections made to the binding posts, and the top of the plug put on and screwed in place. To remove a heating coil, the latter group of operations are reversed. The hexagon coupling, aside from supporting the heating element to the oven, also serves as a packing gland where the end of the coil projects through the oven.

Mercurial control thermometer.

7. The purpose of the mercurial control thermometer is to automatically control the functions of the equipment governing the heat within the oven, this equipment including the relay and circuit breaker on the control panel and the heating coil within the oven. The thermometer is secured to a suitable, flat, hardwood base by two small brass straps. For further support its top end is slightly turned in the form of a hook and secured in the wood base. The whole is placed in the inner copper oven in the pocket provided for this purpose. Two binding posts are mounted on the thermometer base and provide facilities for connecting the contacts on the thermometer (permanently set at 60° and 65.5° C.) with the leads to the electrical controlling panels. These leads should be well insulated, particularly where they pass through the wall of the oven, to prevent a short circuit which would function the relay and cut off the current from the oven.

8. An ordinary mercurial centigrade thermometer, covered by the general requirements of class A of the Navy Department's standard specifications, 18–T–8 of February 2, 1914 (or of later revision), is inserted through the small opening in the cover of the oven and the lower end allowed to rest in an open empty bottle in a wire basket on the inside. This thermometer is used as a check on the accuracy of the control thermometer and to determine the inside temperature of the oven without removing the cover.

Bottles.

9. Each oven is provided with 18 standard 8-ounce salt-mouth "nonsol" glass bottles with plain glass stoppers, which should be loosely attached to the bottles by strings to prevent their being detached in cleaning up or use. In case of doubt as to the tightness of a stopper in a bottle, such stopper should be ground in by hand, using fine emery and a solution of camphor in turpentine. The bottles must be thoroughly washed and dried before using. Near the bottom of each bottle is an etched space for noting, in pencil, the designation of the powder, and the date when put under test.

Wire basket for bottles.

9*a*. The basket for containing the glass bottles is made of a strong wire mesh and of the same shape as the inside of the inner casing of the oven. The wire mesh forming this basket is built up to about the same height as the 8-ounce bottles. Two stout wire handles, which serve to withdraw the basket from the oven, are extended 3 inches above the wire mesh and placed at right angles to one another. These handles are fastened to the basket by wire secured to the wire mesh forming the basket. All joints in the basket are firmly bound together by wire, and a small quantity of solder used where needed.

Control panel.

10. The control panel consists of a substantial polished, black enameled slate slab, 12 inches wide, 16 inches long, and 1 inch thick, on the front of which is mounted the following equipment:

(*a*) One 15-ampere, double pole, single throw, fusible base, back connected knife switch with 10-ampere inclosed fuses.

(*b*) One double coil solenoid circuit breaker.

(*c*) One relay for controlling the functions of the circuit breaker.

(*d*) One Edison base lamp receptacle with 16-candle-power incandescent lamp.

(*e*) One adjustable rheostat to limit the flow of current through the heating element.

(*f*) Four terminal posts, with designation plates, for connection from the control panel to the heating element and control thermometer.

Mounted on the back of the panel are:

(*g*) Resistance coils.

(*h*) Wiring.

Knife switch.

11. The knife switch serves to open and close the main circuit to the oven.

Solenoid circuit breaker.

12. The solenoid circuit breaker, in its normal position, when the inside temperature of the oven is below 65.5° C., forms the path for the current to circulate through the heating element. When the temperature inside the oven rises to 65.5° C., the mercury in the control thermometer closes a circuit through the coil of the relay. The relay then functions, and through platinum-tipped contacts closes another circuit through the coils of the circuit breaker which then operates and disconnects the current from the heating element. The functioning of the circuit breaker also opens and closes a circuit through an incandescent lamp mounted on the front of the panel. When the oven is in operation and the circuit breaker in normal position, the incandescent lamp should burn, and when the armature of the circuit breaker is raised the lamp should cease to burn. As the mercury in the control thermometer rises and falls, making and breaking contact at 65.5° C., the operations outlined above are repeated. The circuit-closing parts of the circuit breaker must be carefully adjusted so that when operated the movable carbon contact blocks do not leave the stationary carbons until the laminated copper contacts have cleared the contact studs by about $\frac{1}{16}$ of an inch. The adjustment must be so made that the copper contacts always carry the current except during the instant the circuit is broken. When adjusted, as stated above, the arc formed by the breaking of the circuit takes place on the carbon rather than at the copper contacts. When the armature of the circuit breaker is operated from its normal position, a small insulated plunger attached to this armature opens a flat spring contact located on the front of the panel just above the circuit-breaker coils. This flat spring is secured to a post at one end and lies against a post at the other end. Normally, it acts as a shunt to a high-resistance coil mounted on the back of the panel. This coil is thrown in series with the coils of the circuit breaker, as follows: When the relay functions, the coils of the circuit breaker get full current in order to life the weight of the armature, etc. After the armature moves upward to about ⅛ of an inch from the solenoids, the insulated plunger, above mentioned, lifts the flat spring, thus breaking the shunt to the circuit-breaker coils and throwing this shunt in series with these coils. This provision is made in order that the coils of the circuit breaker may not overheat.

Relay.

13. The relay is of the solenoid type and its operation has been described above. A small brass plunger extending through the top of the solenoid serves as one of the relay contacts and is held in its normal position above the stationary contact, about ⅛ of an inch, by a light spring installed in the center of the coil. The two contacts of the relay are tipped with small pieces of platinum.

Incandescent lamp.

14. The incandescent lamp is the standard 16-candlepower carbon filament lamp and is installed to serve as a pilot lamp which, when the oven is in operation, indicates whether or not the current is flowing through the heating element, provided, of course, that everything is in proper working order. A lamp of less candlepower would serve the same purpose.

Rheostat.

15. The adjustable rheostat is 10 inches in diameter and consists of highly polished black material, with the resistance coils embedded and held in place at the back by a special cement, and the whole supported in an iron frame. On account of the projection of the thermometer and heater binding posts installed on the panel, the rheostat is so mounted that there is about 1¼ inches of space between the face of the panel and the back of the rheostat. The resistance of this rheostat is about 14 ohms, and the resistance wire is of suitable capacity to conduct 4 amperes at 125 volts. Connection is made to the rheostat from the back and through holes in the slate panel to the proper termination at the back. Around the face of the rheostat there are 36 circular contact buttons spaced a sufficient distance apart to prevent dirt or dust from accumulating and short-circuiting them. These 36 contact buttons represent 35 steps of resistance, the advantage of such a large number of steps being that very close regulation can be obtained. The resistance is adjusted from the front by a highly polished black handwheel, and the direction in which this handwheel should be turned to adjust resistance is indicated on its face by arrows.

Terminal posts.

16. There are four terminal posts at the bottom of the panel, two at the left for connection to the heating element and two at the right for connection to the mercurial control thermometer, both of which are mounted within a circular copper oven. The circuits in which these posts are connected are designated by brass plates fastened to the panel just above each set of posts.

Resistance and wiring.

17. The following is a description of the resistance and wiring:

(*a*) The resistance mounted on the back of the panel, in the upper left-hand corner facing the back, has been previously referred to. This resistance is wound with No. 30 Brown & Sharpe bare German-silver wire and has a resistance of 575 ohms.

(*b*) The resistance on the long tube is divided in three sections and the connections of same can readily be traced by reference to the wiring diagram shown on Plate V.

(*c*) The two end resistances on the 125-volt panels contain 220 ohms and the same resistance on the 80-volt panels contains 130 ohms. The inner resistance on either panel contains 60 ohms. The slight difference in the resistance of the outer coils marks the only difference between the 80 and 125 volt controlling panel. The long tube is wound with No. 34 Brown & Sharpe silk-covered German-silver wire.

(*d*) The small resistance connected across the wires leading to the binding posts for the thermometer circuit is wound with No. 34 Brown & Sharpe silk-covered German-silver wire to a resistance of about 90 ohms. This resistance acts as a condenser and protects the mercury in the control thermometer from the arc subsequent to the breaking of the relay circuit.

(*e*) The wiring of the panel is well insulated, and the back is well protected by a neatly fitted sheet-iron pan held in place by nuts and four heavy brass studs, one in each of the four corners, which also provides for the support of the panel.

(*f*) Wires leaving the back of the panel are passed through suitable holes in the sheet-iron pan. The main leads to the panel should not be less than No. 14 Brown & Sharpe wire, while the feeds to the heating coil and thermometer should be flexible and not smaller than No. 16 Brown & Sharpe. The over-all dimensions of the controlling panel are approximately 18 by 12 by 9½ inches.

Fume tube.

18. The fume tube is about 6½ inches long and ⅝ of an inch in diameter, containing peroxide of nitrogen gas, and is used for comparison with the gases in the bottles containing the powder under test.

To connect oven.

18*a*. To connect oven remove the inside case of oven and see that the heating element is properly installed, pour about 5 quarts of glycerin in the outer case. Replace the inner case, forcing it down into the glycerin until the hasps can be pushed over the staples. Place the electric control thermometer in pocket in inner case, pass the leads out through the holes in side of oven, and connect to the binding posts marked "TH'RM'S'T" on the panel. Remove the wooden cap from protruding end of heater, connect the leads to the two posts exposed, and connect the other end of the leads to the binding posts marked "Heater" on the panel. Put the wire basket filled with sample bottles in place, put cover on oven, place stem thermometer in hole in cover, mount the controlling panel and connect up the main leads, and the oven is ready for operation.

Control panel. **19**. The panel should be mounted within easy reach of the oven on a cool dry place (not over 90° F.), free from dirt and moisture, and in such manner that it will not be subjected to shock or vibration. It may, however, be mounted at any distance from the oven, but it will be found that better results can be obtained if both are located in the same room.

To mount panel. **20**. To mount the panel remove the cover from back and connect a pair of rubber-covered leads not smaller than No. 14 Brown & Sharpe gauge to the line switch studs. Replace cover, passing the leads out through holes in top side of same, and mount panel in a vertical position against a wall or framework, with the line switch at the top left-hand corner. Open the line switch and connect the leads to some suitable and convenient outlet. The voltage for which the oven heater and control panel are wired is plainly marked on each. While the control panel will operate on a voltage not over 10 per cent greater or less than that for which it is rated, it will not operate at all if the voltage varies much in excess of 10 per cent from the normal rating. It will, therefore, be found necessary to make connection with a lamp circuit rather than with a motor circuit, on which sudden heavy loads are likely to be thrown. Connection to a lamp socket is a convenient way of installing. The current required for operation can be varied from 3 to 5 amperes with the rheostat.

To test panel. **21**. To test the control panel.

(*a*) Short-circuit the thermometer binding screws. This will close the circuit of relay which, in turn, closes circuit of solenoid switch through platinum-tipped contacts. As long as the thermometer binding screws are short-circuited, the switch will remain open and the lamp will be dark.

(*b*) *Caution.*—Before closing the line switch examine the relay and make sure that the movable contact works freely. The plunger normally holds the platinum-tipped contacts open about $\frac{1}{16}$ of an inch.

(*c*) If the relay plunger appears to stick and not work freely, it should be removed by unscrewing the lock nut at the top and carefully cleaned of any grit that may have found its way through the opening between the plunger and the lock nut.

(*d*) Great care should be taken not to change the tension of the spring, as this has been very carefully adjusted. When the plunger is replaced, be sure that the slot in the bottom of same fits over the guide with contact in proper position. The flexible lead connecting from the plunger to the panel must be intact. Next examine spring contact of circuit breaker, making sure that contacts are making good electrical connection with stud, then raise solenoid switch and see that when topmost position is reached the insulating tip on plunger has raised spring from stud about ¼ of an inch. The movable carbon blocks on switch should be adjusted so that they do not leave the stationary carbons until the laminated copper contacts have cleared the studs about $\frac{1}{16}$ of an inch.

(*e*) The adjustment must be so made that the copper contacts always carry the current except during the instant the circuit is broken. After the above inspection has been made, screw a lamp into the socket and close the line switch. If proper connections have been made and the fuses are intact, the lamp will burn.

To test thermometers.

22. To test the thermometers, connect thermometer to binding screws on the control panel marked "TH'RN'S'T" with a piece of flexible wire of convenient length, place the bulb of the control thermometer and the chemical thermometer in water heated to a temperature of about 75° C., and close the line switch. Closely watch the chemical thermometer to see that the solenoid switch operates at about the same moment the mercury reaches 65.5° C. Now withdraw the thermometers from the water and watch the thermometer as before to see that the solenoid switch falls at about the same time the mercury drops below 65.5° C. If the spark formed in the thermometer at the instant of breaking the circuit appears unduly long, the small 90-ohm shunt resistance on back of panel may be found open. This resistance is shunted across the thermometer to absorb the "inductive kick" and prevents destructive arcing in the thermometer. A good way to determine whether or not this resistance is open is to raise the line voltage about 10 per cent above normal and short circuit the thermometer binding screws. If closed, the relay contact will not open its full distance when the short circuit has been removed. The undue arcing in the thermometer will tend still to close the relay circuit and will not permit the relay plunger to return to its original position.

Operation of oven.

23. To operate the oven:

(*a*) The basket should be filled with empty sample bottles, and the oven operated one or two days to make sure that everything is in readiness before a test is started. After the current is switched on it will require from one or two hours to bring the temperature up to 65.5° C. As the electric thermometer will probably lag behind the indicating chemical thermometer, it will be found that the temperature will run a little too high at first, but after the rheostat on the control panel has been adjusted so that the current is automatically switched off and on at equal periods of time, the indicating chemical thermometer, the bulb of which should rest on the bottom of an empty sample bottle, will not vary more than 1 degree either way from 65.5° C. Should difficulty be experienced in keeping this temperature, the handles of the wire basket can be lowered, thereby forming four legs on which the basket can be raised from direct contact with the bottom of the oven.

(*b*) Full instructions and precautions in regard to conducting the surveillance test are given in chapter 6, and these must be carefully observed.

(*c*) The compartment or room in which the oven is operated should have as constant a temperature as can reasonably be maintained. If a large change in the, temperature of the surveillance oven compartment is anticipated on board ship the temperature of the oven should be carefully watched, and the rheostats adjusted as necessary to take care of the differences in the outside temperature.

Mark II oven.

24. The Mark II oven was originally designed for operation on an 80-volt or a 125-volt circuit, depending on the heating elements, and were known as the Mark II 80-volt oven and the Mark II 125-volt oven. To avoid misunderstandings and incorrect shipments, the design was altered so that only one oven need be made, and it could be used on either an 80-volt or a 125-volt circuit. Using the same oven, a device was added by which a change of connections to the heating element might be made, so that, depending on the position of a transfer switch, the oven would operate satisfactorily on either an 80 or a 125 volt circuit. Such an oven is known as the Mark II Mod. 1 type. Subsequently another design slightly different in some minor particulars was developed and called the Mark II Mod. 2.

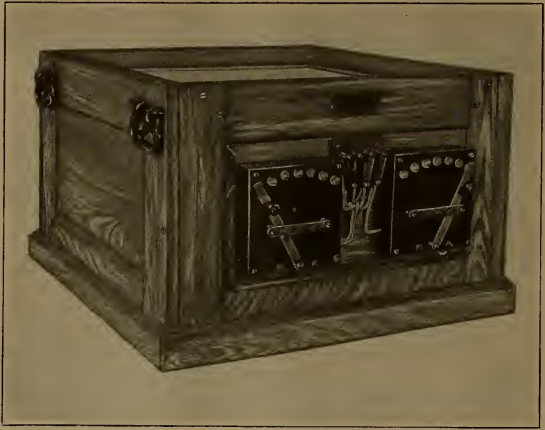


Fig. 30.—Mark II. Oven Showing Rheostat.

Description.

25. The equipment consists of the following principal parts: Heat insulated box and copper oven, mercurial control thermometer, heating element, relay, batteries, rheostats, switch, bottles, fume tube, mercurial centigrade thermometer, and wiring. A perforated copper pan supports the bottles and prevents their direct contact with the bottom of the oven. The body of the oven consists of a well insulated, seasoned hardwood box, with an inner wall of sheet steel. The space between the steel walls and wooden box is well packed with some heat insulating material, such as mineral wool or asbestos. The copper oven, or powder-testing compartment, is a polished sheet copper compartment in which the powder samples are tested. The mercurial control thermometer is used for the purpose of control-

ling the functions of the special relay described later. This thermometer is mounted on a semicylindrical hardwood holder secured to the center of the copper oven bottom by brass screws. The wooden holder is provided with two terminal posts to receive the ends of the wires from the two points on the thermometer (60° and 65.5° C.). Wires are run from the binding posts on the holder through a ferrule in the side of the box and are connected to the relay. All leads are insulated to prevent short circuiting.

Heating element.

26. The heating element is mounted directly under the copper oven and consists of four coils of resistance designed for operation on either 80 or 125 volt circuits. These are so arranged that they are made to function by passing a current through two of the coils for high heat. The constant temperature of 65.5° C. is maintained through the action of the mercurial-control thermometer. The coils are supported and completely incased in a steel pan made in two parts and held together by a center bolt.

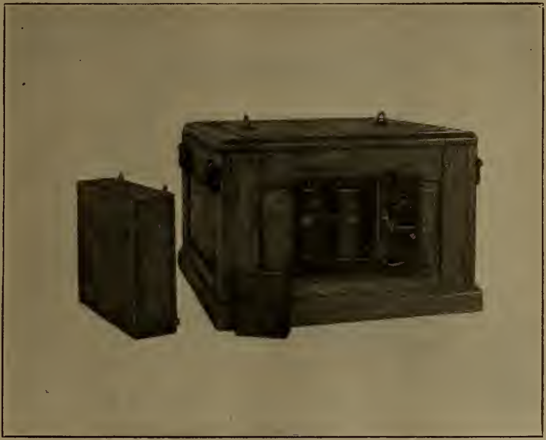


Fig. 31.—Mark II. Oven Showing Relay.

Relay.

27. Mounted on the exterior of the oven on the side opposite to that on which the rheostats are located are a special relay and dry-cell batteries. This relay is mounted on a hardwood base and is energized by the cells through the mercurial-control thermometer, as noted below. When the oven temperature rises to 65.5° C., the mercury in the thermometer closes the battery circuit, which causes the relay to function and to send the heating current through the four coils comprising the low-heat circuit; when the oven temperature falls slightly below 65.5° C., the battery circuit is broken, the relay armature is released, and in returning to its original position short circuits two coils of the heating element. Cutting out these coils causes high heat. In the base of the relay are two condensers, one connected in the circuit of the thermometer and the other in the circuit controlling the heating unit. These are installed for the purpose of and have sufficient capacity to protect from injury the circuit-breaking contact in the mercurial thermometer and that on the armature of the relay. The relay is protected by a suitable cover. The binding posts provided for connection from battery, line, nd from the control thermometer are exposed. These binding posts are marked "Bat," "Line," and "Ther.," respectively.

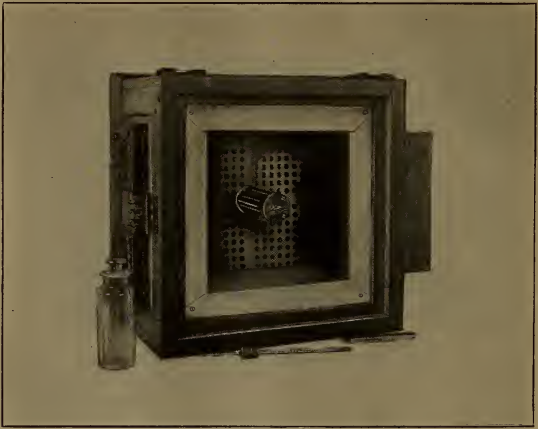


Fig. 32.—Mk. II. Oven Interior.

Battery.

28. The battery consists of two or four high-grade standard dry cells about 2.75 inches in diameter and 6 inches high, exclusive of carbon terminals, which are 1 inch higher. Each cell should give at least 1.5 volts and show about 30 amperes on short circuit. These cells will deteriorate with use and must be regularly inspected.

Rheostats.

29. The two rheostats are located on the side of the oven opposite that on which the relay is mounted. They have a spiral form of resistance inclosed in a base so as to make a moisture and fireproof construction. The rheostat connected to the high-heat circuit of the Mark II Mod. oven has a resistance of about 100 ohms and the one to the low-heat circuit has a resistance of about 150 ohms. Each rheostat is provided with a regulating switch, and the resistance in the rheostat is continuous from the first to the last step.

Switch.

30. A transfer switch is mounted between the two rheostats. It is intended to be set to suit the voltage of the ship—that is, either 80 or 125 volts—and must not be shifted while the oven is being operated at either voltage.

Bottles.

31. Each oven is provided with 24 standard 8-ounce, salt-mouth, "nonsol." glass bottles with plain glass stoppers, which should be loosely attached to the bottles by strings to prevent their being detached in cleaning up or use. In case of doubt as to the tightness of a stopper in a bottle, the stopper should be ground in by hand, using fine emery and a solution of camphor in turpentine. The bottles must be thoroughly washed and dried before using. Near the bottom of each bottle is an etched space for noting, in pencil, the designation of the powder and the date when put in the oven.

Fume tube.

32. The fume tube is about 6.5 inches long by 0.625 inch in diameter, containing peroxide of nitrogen gas and is used for comparison with the gases in the bottle containing the powder under test.

Thermometer.

33. The mercurial centigrade stem thermometer is used to check the accuracy of the mercurial control thermometer. It is graduated in such a manner that the temperature inside the oven may be read without removing the thermometer. This thermometer stem is supported by a cork stopper in a hole of the oven cover.

Wiring.

34. To inspect the Mark II Mod. 1 oven remove the box cover, asbestos board cover, and disconnect wires from binding post of mercurial thermometer, remove copper oven from box. This will leave the heating pan exposed. Now trace the wires leading from the mercurial control thermometer passing through side of box and see that they are connected to the relay binding posts marked "Ther." Connect the two dry cells in parallel, and secure wires to the binding posts of relay marked "Bat." (The wires from dry-cell battery are the only ones not passing into box.) Carry the wire leading from either relay binding post marked "Line," through side of box and over the heating element through ferrule in opposite side of box, connecting it to the right-hand binding post of 150-ohm rheostat, which connects to positive line of ship's circuit. (In running all wires through box, allow enough wire to permit them to lie loosely on top of or around the heating pan, in order that the copper oven may rest securely on the oven supports of heating pan when copper oven is fastened to box.) Carry the wire from the other binding post of relay marked "Line," through box and out on opposite side, connecting it to the binding post at the bottom of "transfer switch" which is adjacent to 150-ohm rheostat. Connect the wire leading from coil No. 3 (which is connected to coil No. 4) to top of binding post of "transfer switch" adjacent to 150-ohm rheostat. Connect the wire from coil No. 1 (which is connected to coil No. 4) to binding post at the top of "transfer switch" second adjacent to 150-ohm rheostat. Connect the wire from second post of coil No. 1 to bottom binding post of "transfer switch" which is adjacent to 100-

ohm rheostat. Connect either wire leading from coil No. 2 to middle binding post at bottom of "transfer switch," and the other wire from coil No. 2 to binding post of 150-ohm rheostat adjacent to "transfer switch." Connect the wire leading from coil No. 3 to binding post of "transfer switch" second adjacent to 100-ohm rheostat. Connect the wire from bottom binding post of "transfer switch" adjacent to 100-ohm rheostat to binding post of 100-ohm rheostat farthest from "transfer switch." Replace copper oven, passing the two wires leading from relay marked "Ther." through holes in base of mercurial control thermometer support and connect to binding posts of same. Lastly, connect the positive line of ship's circuit to binding post of 150-ohm rheostat farthest from "transfer switch" and the negative line to binding post of 100-ohm rheostat adjacent to "transfer switch." The foregoing describes the wiring diagram shown on Plate 54 (appended). Great care must be taken to see that all wires are securely fastened to their respective binding posts.

Operation.

35. For operating the oven:

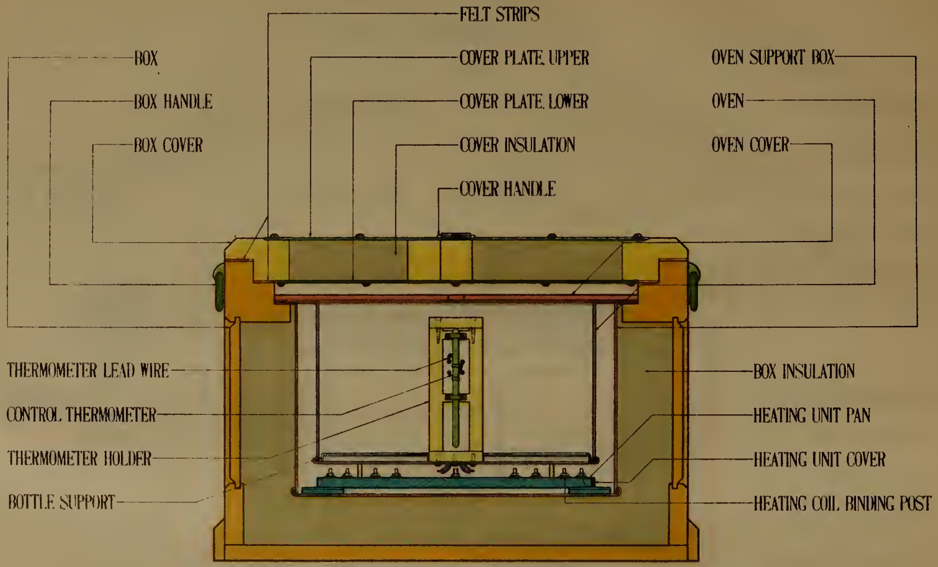
(*a*) In making an actual test, the oven is heated to 65.5° C. with the high-heat coils, at which temperature (within a permissible fluctuation of plus or minus 1° C.) the control thermometer automatically closes the battery circuit through the relay, which in turn operates and connects the low-heat coils in circuit. The heat then gradually decreases until the temperature of the oven falls below 65.5° C., when the mercurial control thermometer opens the circuit and releases the relay armature to its original position, thus short circuiting the low-heat coils and switching in the high heat.

(*b*) Before proceeding with the test proper always operate the oven containing the 24 empty bottles at least 24 hours at approximately the correct temperature, 65.5° C., to dry the oven and to obtain constant conditions. The wattage can then be adjusted by means of the rheostats, so that the variation in temperature will not exceed 1 degree from the normal. Although the ovens are designed to take care of fluctuation of room temperature, it is best to adjust the rheostats so that the low-heat coil will supply almost enough heat to maintain the required temperature. Otherwise, the relay will be called upon to operate often, which should be avoided as much as possible. Sufficient time must elapse between each adjustment to insure a constant temperature throughout the oven. Best results are obtained when high heat is set at 60 watts and low heat at 30 watts, in a room temperature of 23° to 26° C. This applies when the ovens are connected to either 80 or 125 volt circuits.

(*c*) Full instructions and precautions in regard to conducting the test are given in chapter 6, and these must be carefully observed.

(*d*) The compartment or room in which the oven is operated should have as constant a temperature as can reasonably be maintained. If a large change in the temperature of the surveillance oven compartment is anticipated on board ship, the temperature of the oven should be carefully watched and the rheostats adjusted as necessary to take care of the differences in the outside temperature.

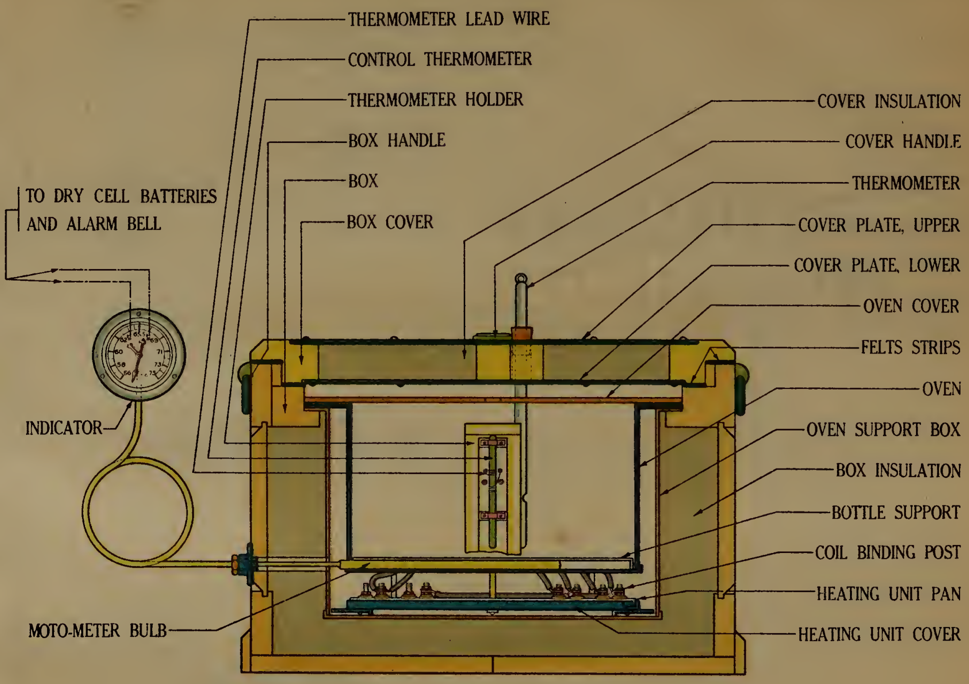
PLATE V.



VERTICAL SECTION THRU OVEN.

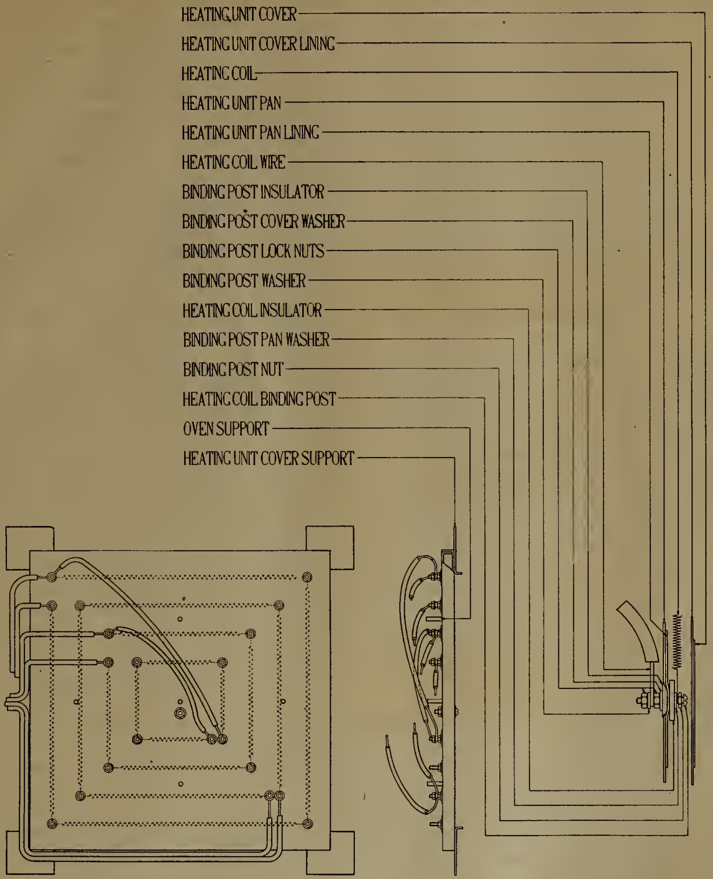
Surveillance Oven, Mark II, Mod. 1.

PLATE VI.



VERTICAL SECTION THRU OVEN.

Surveillance Oven, Mark II, Mod. 2.



Surveillance oven, Mark II, Mod. 2. Heating Unit and Coil Connections.

Mark II, Mod. 2. **36.** The Mark II Mod. 2 survelliance ovens differ from the Mark II Mod. 1 ovens described in preceding paragraphs only in the following particulars:

(*a*) The battery operating the relay consists of four dry cells arranged in two groups of series parallel, two in series and two in parallel, while the battery in the Mark II Mod. 1 oven consists of only two dry cells joined in parallel.

(*b*) The 100-ohm high-heat rheostat has been replaced by one of 35 ohms.

(*c*) The 150-ohm low-heat rheostat has been replaced by one of 400 ohms.

(*d*) A 35-ohm resistance tube has been mounted on the outside of the oven box and connected in series with the low-heat rheostat.

(*e*) A slight change has been made in the design of the switch for adapting the oven to either 80 or 125 volt circuits and a slightly different method of connection between the heating unit and this switch has been employed.

(*f*) A wiring diagram showing the various connections of this oven is shown on Plate 11.

(*g*) The method of operation is the same for the Mark II Mod. 1 and Mark II Mod. 2 ovens.

Mechanical thermometers or motometers. **37.** Motometers, which are mechanical thermometers, are being furnished to a number of the latest type vessels as a result of successful tests on the *Tennessee*. These motometers are identical with the instruments found on some automobiles except in the graduation of the registering dial and the addition of electric contacts to operate an alarm bell.

38. A number of surveillance ovens have been seriously damaged and valuable tests have been interrupted due to the failure of control thermometers on surveillance ovens resulting in overheating of the ovens. Indicating dials of the motometers are graduated from 56° to 75° C. with a mark at 65.5° to show the temperature desired. At 68° contacts are provided to operate an alarm circuit, the bell of which may be installed wherever it may be most effective. There is 15 feet of tubing between the bulb (which must be placed in the temperature to be registered) and the registering dial. This allows the dial to be placed outside the test room on the bulkhead or anywhere where it can be conveniently observed.

39. A blue print will be furnished with each motometer showing the method to be used in installing it.

40. The description and operation of this oven is practically the same as the Mark II Mod. 1 except in the following particulars:

(*a*) The equipment consists of a resistance tube in addition to that given above for the Mark II Mod. 1.

(*b*) The heating unit consists of four coils so arranged that they are made to function by passing a current through a combination of these coils for high heat and through another combination for low heat, on either an 80 or a 125 volt circuit. The method of combining these coils to obtain the high and low heats for these voltages is shown on Plates 11 and 12.

(*c*) The operation of the relay sends the heating current through the coils comprising the low-heat circuit when the temperature rises to 65.5° C.; when the oven temperature falls slightly below 65.5° C., the battery circuit is broken, the relay armature released, and in returning to its original position brings the proper high heat coils into circuit.

(*d*) The battery consists of four instead of two cells.

(*e*) The high-heat rheostat has a resistance of 35 ohms and the low heat one of about 400 ohms. Each rheostat is marked to indicate the direction of operation to cut resistance in or out of circuit.

(*f*) On the same side of the oven with the rheostat and transfer switch, and near the base, is mounted a 35-ohm resistance tube which can be readily removed or replaced. This tube is connected in series with the low-heat rheostat.

Wiring.

41. To inspect a Mark II Mod. 2 oven, remove the box cover, asbestos board cover, and disconnect wires from binding post of mercurial control thermometer, remove copper oven from box. This will leave the heat pan exposed. Now trace the wires leading from the mercurial control thermometer passing through the side of box and see that they are connected to the relay binding posts marked "Th." Connect the four dry cells in two groups of two in series and the two groups then connected in parallel and secure wires to the binding posts of relay marked "Ba." (The wires from dry-cell battery are the only ones not passing into box.) Carry the wire leading from either relay binding post marked "Line" through side of box and over the heating element through ferrule in opposite side of box, connecting it to the left-hand binding post of 400 ohms rheostat, which connects to positive line of ship's circuit. (In running all wires through box, allow enough wire to permit them to lie loosely on top of or around the heating pan.) Carry the wire from the other binding post of relay marked "Line" through box and out on opposite side, connecting it to the binding post at the bottom of "transfer switch" which is adjacent to 35-ohm rheostat. Connect the wire leading from coil No. 3 (which is also connected to coil No. 4) to bottom binding post of "transfer switch" second adjacent to 400-ohm rheostat. Connect the wire from coil No. 1 (which is also connected to coil No. 4) to binding post at bottom of "transfer switch" second adjacent to 400-ohm rheostat. Connect the wire from second post of coil No. 1 to top of binding post of "transfer switch" which is adjacent to 35-ohm rheostat. Connect one wire leading from coil No. 2 to middle binding post or "transfer switch" and the other wire from coil No. 2 to 35-ohm resistance tube. Connect one wire leading from coil No. 3 to binding post at top of "transfer switch" second adjacent to 400-ohm rheostat. Connect the other leading from coil No. 3 to bottom binding post of "transfer switch" adjacent to 400-ohm rheostat. Connect the wire from bottom binding post of "transfer switch" adjacent to 35-ohm rheostat to binding post of relay marked "Line." Connect the wire from top binding post of "transfer switch" adjacent to 35-ohm rheostat adjacent to "transfer switch." Replace copper oven, passing the two wires leading from relay marked "Th" through holes in base of mercurial control thermometer support and connect to binding posts of same. Lastly, connect the positive line of ship's circuit to binding post of 400-ohm rheostat farthest from "transfer switch" and the negative line to binding post of 35-ohm rheostat farthest from "transfer switch." The foregoing describes the wiring diagram shown on Plate 55 (appended). Great care must be taken to see that all wires are securely fastened to their respective binding posts.

Test. **42**. In making an actual test, the oven is heated to 65.5° C., with the high heat coils, at which temperature (within a permissible fluctuation of plus or minus 1° C.) the control thermometer automatically closes the battery circuit through the relay, which in turn operates and connects the low heat coils in circuit. The heat then gradually decreases until the temperature of the oven falls below 65.5° C., when the mercurial control thermometer opens the circuit and releases the relay armature to its original position, thus bringing the high heat coils into circuit.

Ovens in service. **43**. All Mark II ovens have been or will be modified to the Mark II Mod. 2 when turned in for repair. All Mark II Mod. 1 ovens are to be modified to the Mark II Mod. 2.

Chapter VIII.

HIGH EXPLOSIVES.

1. In chapter 3 it was pointed out that explosives can not be definitely classified by their chemical composition, but that they are classified, by the speed of the chemical change, into propellants and high explosives. A high explosive for military use as a burster charge has two distinguishing features. It is, first, relatively insensitive to mechanical shock, friction, flame, etc., and even when exploded by such means does not give full explosive effect; second, the whole charge decomposes almost instantaneously when subjected to the proper impulse. The list of substances which can be grouped under the term high explosives is a long one, but this list is materially reduced when those not suited for military purposes are eliminated.

Requirements of high explosives.

2. The following conditions must be fulfilled by a military high explosive. It must—

(*a*) Have the proper insensitivity to withstand—

(1) shock of gunfire;
(2) shock of impact against armor, if used for projectile filler;
(3) shock of handling.

(*b*) Have maximum power.

(*c*) Have stability to withstand adverse storage conditions due to heat, moisture, etc.

(*d*) Be easy to handle and load.

(*e*) Produce proper fragmentation.

(*f*) Be cheap and available, and easy to manufacture.

All these conditions must be considered, and the substance most nearly fulfilling them all is the best high explosive. However, the uses to which the high explosive is to be put must be considered, for a projectile filler must fulfill all these conditions while a mine or depth charge filler, for instance, need not be so insensitive as to withstand armor impact.

Sensitivity.

3. The sensitivity to shock is measured by the so-called impact test, wherein a given weight is dropped on measured quantities of the explosive under test and the height of the drop causing an explosion is taken as a measure of the sensitivity. This test gives a relative measure and is of value only so long as the conditions are the same. The amount used, the degree of pulverization, the hardness of the face of the apparatus, the density, the mixture with other substances, all these things will affect the test. Some explosive substances can be compressed so that they become practically inert, this condition being called "dead pressed." Sensitivity to friction is measured by subjecting samples to the friction due to sliding impact of a shock pendulum across the face of an anvil upon which the sample rests. The arc of the swing of the pendulum gives the standard of measure. Sensitivity to heat is determined by measuring the flash point of the explosive.

Power.

4. It is very difficult to get an absolute measure of the power of an explosive. Although the temperature, pressure, and volume of the products of combustion can be determined, the behavior of the products at the high temperatures and pressures makes it difficult to determine an expression for power. Approximations have been made, but probably as good a method as any is the result obtained by using the Trauzl lead block test. It is made by firing charges of different explosives in a standard-sized hole, in a lead block, and measuring the increased volume. The relative power is obtained by the variations in the increased volumes. The effect of the time in which the explosive develops its maximum pressure is also considered in connection with the power. The "rate of detonation" is measured by timing the passage of the detonating wave between two points of a cord or column of the explosive. The violence of the blow, called the "brisance," is particularly considered in connection with detonators.

Adaptability.

5. An explosive which catches fire easily and explodes when lighted is more dangerous for military uses than one which ignites with difficulty and burns quietly. Also, a high explosive must retain its stability under all conditions of storage, as it would be most difficult to determine the stability condition of separate large cast or compressed charges. In particular the explosive must hold up against adverse hygroscopic conditions and remain effective though wet, as in a leaky mine case or in a torpedo war head. In addition, the facility with which a high explosive can be assembled into a charge is very important. One which can be melted at moderate temperatures and cast, permits of loading into irregularly shaped volumes very easily. The explosives used must permit of easy handling without danger to personnel by accident or toxic effect.

Availability.

6. Many explosives, otherwise very suitable, are unsatisfactory due to the small yield, scarcity of raw materials, and difficulties in manufacture.

List of high explosives.

7. From a consideration of the above-mentioned factors, the following list of explosive substances have been or are standard for military use:

Guncotton.—Superseded by T. N. T.

Trinitrotoluol.—T. N. T.

Trinitroxylol.—T. N. X., sometimes used in mixture with T. N. T. A small quantity was manufactured during the war; none is in service at the present time.

Trinitrophenol.—Picric acids used as a projectile filler, (not in United States Navy) and in boosters or relays for fuzes.

Ammonium picrate (Explosive "D").—Used as a projectile filler.

Trinitrocresol.—Similar to picric acid, used, when mixed with picric acid, in Austria.

Trinitro-aniline.—Not used on a large scale.

Trinitrophenylmethylnitramine, tetranitromethylaniline or tetryl.—Used for booster charges and relays; costly to manufacture.

Tetranitroaniline.—Costly to manufacture; not entirely established.

Hexanitrodiphenylamine.—"Hexa," used by Germany mixed with T. N. T.

Amatol.—T. N. T. and ammonium nitrate.

Nitrostarch.—Trojan powder used in hand grenades.

Trinitrobenzene.—Costly and difficulty to manufacture with low yields; very little manufactured.

Guncotton.

8. The first modern high explosive to come into general use was guncotton. It is a cellulose nitrate of high nitration with about 13 per cent nitrogen content. It was manufactured in a manner similar to that given for soluble nitrocellulose under the discussion of smokeless powder, except as to strength and mixture of acids and time for nitration. It is similar to ordinary cotton in appearance and, when pure, is white and has neither odor nor taste, and is free from either alkaline or acid reactions. After poaching, it is compressed into blocks containing about 25 per cent moisture, and these are packed into war heads and mines. In England war heads were loaded by compressing the full charge into a former of the shape of the war head, and then loading in one operation. Due to its sensitivity when dry, its liability to deteriorate, and its low power as compared with other high explosives, it has been superseded for the most part by T. N. T. In the United States Navy it is being replaced by T. N. T.

Source of raw materials.

9. A glance at the list given above will show that most high explosives are derived from coal-tar products. When coal is subjected to destructive distillation, coke, gas, and coal tar are obtained. This coal tar is a heavy liquid of a complex mixture which, on further distillation, will yield the aromatic hydrocarbons, benzene, toluene, xylene, naphthalene and anthracene, and the aromatic alcohols phenol and cresol. The distillation of petroleum will also yield toluene, xylene, benzene, and naphthalene. From these substances, or from other substances obtained from them, explosives may be made by nitration. Some of these substances are used in the dye industry, so that it is closely connected with the explosive industry.

Benzene.

10. Benzene, when nitrated once, becomes mononitrobenzene. This compound is used for perfumery and flavoring. When nitrated again it becomes dinitrobenzene, an explosive very difficult to detonate and used only when mixed with other explosives. When nitrated again trinitrobenzene is formed, but it is very difficult to manufacture and although it is an excellent explosive, being more powerful than T. N. T., it is little used.

Toluene and T. N. T.

11. Toluene is nitrated either to a monodi or trinitro product. Mononitrotoluene is not an explosive substance. Dinitrotoluene is a substance difficult to detonate and is used only to mix with other explosives to reduce their sensitivity.

Nitration.

Trinitrotoluene is made in one, two, or three operations, but the best yield is obtained by using the two or three stage process. In the one-stage process the acids are run into a large nitrator or kettle, equipped with heating and cooling coils, and the toluene is then added slowly. When the action is completed, the mononitrotoluene and spent acids are allowed to separate, the acid drawn off and the mono-oil, as it is called, blown into a second nitrator, into which fresh acid has been run. After this action is completed, the charge is allowed to separate and the spent acid is run off and fresh acid added to make the T. N. T. by a third nitrating step. After this last spent acid is removed, the T. N. T. is cooled, washed and crystallized out as the temperature is reduced. By this method of manufacture the spent acid from the trinitration is used after fortifying for the binitration, and the spent acid from the binitration is then used for the mononitration.

Uses of T. N. T.

12. T. N. T. is a crystalline substance, of a light yellow color when pure, and varying in shade to a dirty brown when impurities are present. When pure it melts at about 80.5° C. To get a product of this purity it is necessary to recrystallize it in alcohol or some other solvent. Its purity is shown by its melting point. In the Navy two grades are used, Grade "A," having a melting point of 79.5° C., and Grade "B," having a melting point of 75.5° C. It is sometimes used in the nearly pure state for boosters for fuses, and then has a melting point of 80.5° C. It is practically insoluble in water. Grade "A" is used for a projectile filler for class B antiaircraft projectiles (for this purpose the T. N. T. is always cast), for mixed filler for common projectiles, and for boosters for the cast mine charges (granulated). Grade "B" (T. N. T.) is used for main cast charges for torpedo war heads, mines, depth charges, and bombs.

Properties of T. N. T.

13. T. N. T. is neutral in reaction and, unlike picric acid, does not form sensitive compounds by combination with metals, even under unfavorable conditions of moisture and temperature. It has high chemical stability, even when subjected to temperatures as high as 150° F., for considerable periods of time. It can stand great variations in temperature without being affected. Although the specifications for T. N. T. require rigid purification and elimination of all acids, its stability does not appear to be affected by traces of acids. Caustic alkalies, on the other hand, are known to increase its sensitivity and should be carefully avoided. It has been found that T. N. T. darkens on exposure to light and the melting point is somewhat lowered.

Other properties of T. N. T.

14. T. N. T. is relatively insensitive to shocks, friction, or pressure. When ignited, unconfined, it burns slowly with a dense black smoke and without explosion. It ignites at 300° C., and at 180° C. there is a slow evolution of gas. Experiments made at the proving ground indicate that in case of a serious fire near or among T. N. T. charges, a violent explosion is probable. Incidents have been reported from abroad where T. N. T. in storerooms has exploded during a fire, consequently this danger should always be kept in mind. T. N. T. can be melted readily in kettles with steam or hot water jackets, or, due to its specific gravity, may be melted in a hot water bath where it drops to the bottom and may be drawn off in liquid form. In the melted form it has the appearance of melted maple sugar, solidifying like maple sugar when cooled. When melted it can be cast solid in any shape desired. This property makes it a very convenient substance for explosive charges in mines, torpedoes and bombs, and it is now in general use in most countries for this purpose. Grade "B" gives as powerful explosive effects as Grade "A" and is considerably cheaper to make

Explosive force.

15. The explosive force of cast T. N. T. is about 10 per cent greater than wet guncotton for equal weight and somewhat greater than this for equal volume, as its density is greater. The density of wet guncotton is about 1.3. The density of cast T. N. T. runs from 1.50 to 1.61, and of loose crystalline T. N. T. from 0.75 to 1 (hand packed). Loose crystalline T. N. T. is frequently compressed for certain purposes (such as projectile filler when mixed filler is used), its density when compressed varying from 1.2 up to about 1.5, depending on the pressure.

T. N. T. boosters.

16. Cast charges of T. N. T. are very difficult to detonate directly and a "booster" of loose crystalline T. N. T. (Grade A) is used to transmit the detonation of the fulminate detonator to the cast main charge. This is analogous to the use of boosters of dry guncotton to detonate main charges of wet guncotton. Unlike dry guncotton boosters, the crystalline T. N. T. boosters may be stored aboard ship directly in the cast main charges.

Moisture in T. N. T.

17. Contrary to certain of the published literature on the subject, experiments conducted at the proving ground and at the torpedo station show conclusively that the presence of moisture adds greatly to the difficulty of detonating T. N. T., and probably decreases its explosive force. Five per cent moisture, or even less, will cause a "booster" charge of hand-packed crystalline T. N. T. to fail altogether when using a service detonator, although dry guncotton will detonate successfully under these conditions. It is of the greatest importance that T. N. T. boosters be kept *dry* in service.

Comparison with "D."

18. Although extensively used as a projectile filler for field artillery ammunition for class B antiaircraft projectiles, and with black powder as a mixed filler in small-caliber common projectiles, T. N. T. is inferior to explosive "D" for use in armor-piercing projectile against thick plate, as it is more sensitive to shock and is therefore liable to premature explosion on impact, particularly with pressed charges.

Uses of T. N. T.

19. T. N. T. is used in the United States Navy for the following purposes:

(*a*) For main charges of torpedo war heads and mines wet guncotton has been superseded by cast T. N. T. and the dry guncotton booster charges have been superseded by Grade A granulated T. N. T. booster charges. There is very little guncotton left in service; what little there is is rapidly being replaced with T. N. T. Cast charges are ordinarily made of "crude" T. N. T., although the "refined" may of course be used if no "crude" is available. *"Crude" Grade B T. N. T. is used only for cast charges*, for which purpose it is entirely satisfactory as to stability, is equal to the "refined" in explosive force, and is considerably cheaper, the only objection to it being that under long stowage it gives off a dark-brown liquid, (*b*) For booster charges for torpedo war heads and mines loose, crystalline, "refined" T. N. T. (Grade A), hand packed to a density of 1, is used. The weights of the booster charges vary from about one-half of 1 per cent to 2 per cent of the cast main charge. Not only are T. N. T. boosters supplied for all cast main charges of T. N. T., but they have replaced the dry guncotton boosters for all torpedo war heads and mines now loaded with guncotton, the advantages being the elimination of all stability tests now required for dry guncotton and the feasibility of stowing the T. N. T. boosters directly in the war heads or mine charges.

(*c*) For burster charges of "class B" antiaircraft and antisubmarine flat-nose projectiles a number of 3-inch field-gun "class B" projectiles have been issued to the service; these are loaded with compressed, crystalline, refined T. N. T., and fused with nose-detonator fuses. A number of "flat-nosed" nonricochet projectiles of from 3-inch to 6-inch caliber fitted with nondetonating fuses for antisubmarine work and a supply of 3-inch "class B" projectiles fitted with time fuse and detonating element for antiaircraft work are being issued. The last two classes of projectiles are loaded with cast T. N. T. Grade A.

(*d*) For mixed burster charges for projectiles fitted for ignition fuses, it has been found that black shell powder alone has too little force to properly fragment 3, 4, and 5 inch "armor-piercing" projectiles and also many tough "common" projectiles of various calibers. For these projectiles a burster charge, consisting of equal parts by weight of T. N. T. and black shell powder, has been adopted. This filler is considerably more powerful than black powder alone and insures excellent fragmentation of the projectiles mentioned. This mixed filler is termed the "T. N. T.-BP" shell filler. A similar mixed shell filler, consisting of equal parts by weight of explosive "D" and black shell powder and termed the "D-BP" filler, is sometimes used. The high explosive is always placed in the nose of the projectile, for if placed next to the ignition fuse the burster charge would not be set off.

(*e*) A special refined grade of crystalline T. N. T. is used for the booster charges of the Mark III tracer detonator fuse.

Care in storage and handling.

20. Like other explosives, T. N. T. should not be subjected to high storage temperatures or exposed to the direct rays of the sun. Particular attention must be paid to keeping T. N. T. primers *dry*.

(*a*) T. N. T. should not be subjected to contamination of any kind, such as dirt, oil, acid, or *alkali*. It should be handled as little as possible.

(*b*) In case of a serious fire it should be remembered that charges of T. N. T. are more inflammable than charges of wet guncotton. For this reason it is important that magazines containing T. N. T. charges should be fully equipped with flooding and sprinkling systems.

(*c*) T. N. T. boosters for all war heads previous to Mark VII are inserted in the booster tube in which dry guncotton booster blocks were formerly placed. The heads are stowed with the war nose removed and a removable wooden block in its place. This block is held in position by a nose piece. In removing this block and in inserting the war nose, care should be exercised that the T. N. T. remains in place and does not break up so as to foul the projecting detonators of the war nose, as serious danger might otherwise result. There should be at least ⅛ inch clearance between the bottom of the detonators and the T. N. T. boosters when the war nose is screwed all the way in. More detailed instructions are given in Ordnance Pamphlet No. 415, revised, 1916 (Pamphlet on Mark V War Nose). In all Mark VII and subsequent war heads, the T. N. T. booster is entirely incased in a copper container and is separated from the detonator by a copper wall about 0.02 inch thick. The method of inserting the detonator and exploder mechanism is fully described in Ordnance Pamphlet No. 377 (War Head Attachments).

Liquid isomers of T. N. T.

Exudation.

21. A small quantity of a dark-brown, oily liquid frequently separates out from cast charges of crude (Grade B) T. N. T. after a period of storage. Investigation has indicated that this liquid consists of isomers of T. N. T. (material of same chemical formula but different molecular structure), with a small percentage of lower nitrotoluols. This liquid is somewhat inflammable (like T. N. T.), but it is not sensitive to shock or percussion, and its presence does no harm either to the stability or explosive force of the main charge. Although less sensitive to detonation than straight T. N. T., it appears probable that this liquid is detonated with the main charge. No danger or loss of efficiency must be apprehended from the presence of this liquid, and its presence may be considered as a normal condition of cast crude T. N. T. charges.

Trinitroxylene (T. N. X.).

22. Trinitroxylene, or T. N. X., is made in a manner similar to T. N. T. Due to difficulties in obtaining T. N. T. during the World War, this explosive was produced to supplement the available supply of T. N. T. The raw materials were available, and it fulfilled practically all requirements except that of ease in handling. Xylene is a higher boiling hydrocarbon than toluene and T. N. X. and has a higher melting point than T. N. T. so that it can not be cast directly in mine charges, and this high melting point also complicates manufacture. It has another drawback in that the yield is less than with T. N. T. The nitration is carried out in three stages, the first two in the same nitrator, and the third in a different one. The acids are handled as in the manufacture of T. N. T. in three stages, i. e., the tri-spent acid is fortified and used as the bimixed, and this spent acid is again fortified and used as the monomixed acid. The monospent acids are denitrated and used in the acid plant.

Manufacture of T. N. X.

23. The proper amount of acid is run in the nitrator, and the xylene added slowly, the acid drawn off to be used over again. The agitators in the nitrating kettles are started and the monomixed acids added slowly, so that the temperature does not rise very materially. Cold water is run through a series of coils in the nitrator to keep the temperature down. After the agitator has continued for about an hour, the charge is allowed to settle, and in settling the acids and mononitroxylol separate. The acids, being the heavier, settle at the bottom of the nitrator where they are drawn off. This completes the first stage nitration operation. The bimixed acid is then added slowly, the charge agitated and cooled with water. During the latter part of the reaction, if the charge cools too much, steam is used, for which there is a connection to the water coils. After the reaction is completed, the charge is again allowed to settle and the spent acids are drawn off as before, fortified, and then are used over for the first stage nitration on a following round. The bioil as it is called (the dinitro-xylol), is then forced by air to the scale tanks for the third stage nitration, being careful to keep it heated, as it becomes solid at room temperature. In the third stage, the bioil is added after the tri-mixed acids have been run into the nitrator and the agitation started, controlling the temperature by the cooling coils. The product now becomes a thick mush of T. N. X. mixed with acid with an amount of D. N. X. mixed with it. As the acids will not separate out, it is now necessary to pass the product through centrifugal wringers, and after that it is thoroughly washed, neutralized by the addition of bicarbonate of soda, dried in a hot air continuous drier, and finally screened and packed for shipment. The T. N. X. becomes solid in the third stage nitration and thereafter is in a granular form, sometimes quite lumpy.

Properties of T. N. X.

24. T. N. X. is a yellowish granular powder similar in appearance to T. N. T., but it has a melting point of 165° C. (circ.). It can be used as a mine, depth, or war head charge and is readily loaded when mixed in about a 50–50 proportion with molten T. N. T. None of this material is in service at present, but circumstances may require its manufacture at some future date, so a small amount is now on hand at the ammunition depots. As with T. N. T., no special tests are required for T. N. X., as it is stable under all ordinary conditions of storage.

Picric acid.

25. Trinitrophenol, or picric acid, was adopted by several foreign countries as a projectile filler as early as 1886, under the name of "melinite." It was used in the cast form by the British as "lyddite," and by the Japanese as "shimose". It has appeared as a component in a number of other explosives. It is a yellow crystalline substance, soluble in alcohol, benzene, and only slightly soluble in water. It is used in the dye industry and in solution for treating burns. It has the property of forming very sensitive compounds with metals, especially with lead. As it is an acid, these compounds are salts and, as they are very dangerous, they must be avoided. With ammonia it forms a compound, ammonium picrate, which is comparatively insensitive and has been much used as a military explosive. Picric acid melts at 122° C. If stored properly it shows no tendency to decompose at moderate temperatures. It is more sensitive than T. N. T. to shock and friction.

Manufacture of picric acid.

26. Picric acid is a very powerful explosive. It is made from phenol or carbolic acid, which is melted in an iron kettle with sulphuric acid, making phenol-sulphuric acid. This is then treated with nitric acid in a nitrator from which, after, cooling, the spent acid is removed and the crystals washed and dried. Due to the fact that picric acid forms dangerous salts, and to the fact that it will deflagrate on contact with heavy armor, its use as a high explosive in this country has been limited. It is sometimes used in boosters of fuses.

Ammonium picrate. "Explosive D."

27. Ammonium picrate, "Explosive D," has been adopted by the Navy as a filler for armor-piercing projectiles due to its insensitivity. It reacts much more slowly than picric acid in forming metallic salts, in fact in an almost negligible quantity when dry. When wet it reacts slowly to form metallic picrates. Its trade name is "Explosive D." It is an orange-colored, crystalline powder, varying slightly in color. It has high chemical stability, no acid products indicating decomposition being observed, even when subjected to temperatures as high as 150° F. for considerable periods of time. Ordinary variations in temperature have no effect on "D," but it should not be exposed to moisture as it will absorb up to 5 per cent moisture, thereby losing power and sensitivity, as well as having a tendency to form metallic salts, if permitted to. "D" is highly insensitive to shock, friction, and pressure. It does not dead press, and can not be melted like picric acid, but when heated to 300° C. explodes. On account of its insensitivity, it is much better than picric acid or T. N. T. for armor-piercing projectiles, as it will stand the shock of impact against any thickness of armor if properly loaded. The Trauzl test shows that cast T. N. T. is more powerful than "D," as "D" is ordinarily used, due to the fact that cast T. N. T. can be loaded to a great density.

Characteristics of "D."

28. When "D" is ignited and not confined, it burns slowly, with dense black smoke, and without explosion. If confined and heated to the ignition temperature, it will explode. It requires a very strong detonation to explode it. On complete detonation it gives off a dense cloud of black smoke with a sooty deposit, due to the carbon freed in the reaction, and leaves a smell of ammonia in the vicinity. This is called a "high order detonation." When "D" deflagrates, and when the full explosive effect is not experienced, yellow smoke is observed and particles of unburned "D" remain. This is called a "low order detonation."

Use of "D."

29. Ammonium picrate has been known for many years as an explosive. About 1870, propellant powders, consisting of a mixture of ammonium picrate and saltpeter, were introduced in France. These powders gave excellent results, being much more powerful than the black powder then in ordinary use, but they were later superseded by smokeless powder. Up to about 1907 a mixture of ammonium picrate and saltpeter was used in the British service as the "exploder" for projectile burster charges of lyddite. Later, this mixture, which was known as "picric powder," was superseded by "tetryl." So far as known, the United States is the only country using straight ammonium picrate as the burster charge for high explosive projectiles at the present time.

Manufacture and use of explosive "D."

30. Ammonium picrate is made by saturating a hot solution of picrate acid with aqua ammonia or ammonia gas. This results in neutralizing the acid and is shown by the formation of crystals. The solution, when the reaction is complete, is dumped into crystallization tanks where the ammonium picrate crystallizes out, this action being assisted by agitation. The crystals are then removed, filtered, dried, and screened, and the powder is then ready for packing. It is used primarily as the burster charge for large-caliber projectiles fitted with detonating fuses. It is packed in the projectile cavities under pressure. A projectile not to be used against armor may have T. N. T. substituted for "D." Certain projectiles using ignition fuses are loaded with a mixer filler composed of "D2" and black powder. The black powder is not sufficiently powerful alone, but with the "D" mixed with it a more satisfactory fragmentation is obtained. The "D" when thus used is not detonated, but deflagrates in a "low order explosion." A detonating fuse is not required for this mixture as ignition of the mixture produces the desired action.

Care of sulphuric "D."

31. Like other explosives, "D" should not be subjected to high temperatures nor exposed to the direct rays of the sun. It should be kept thoroughly dry and not subjected to contamination of any kind, such as dirt, oil, or acid, or such alkalis as lime, especially, and it should not be left in contact with unprotected metal surfaces, especially lead. Aboard ship, "D" is found only in loaded projectiles and requires no special care, except to see that the projectile rooms are kept thoroughly dry and at moderate temperatures. In case of fire in the vicinity of projectiles, care should be taken to see that they do not become heated to a high temperature as the "D" might explode. In such cases, they should be kept cool by the use of the sprinkler system. No special tests or inspections of ammonium picrate are required afloat.

Tetryl.

32. Trinitrophenylmethylnitramine, tetryl, or tetranitromethylaniline, as it is sometimes called, is another aromatic nitrocompound which has come into use as a booster material. It is about 18 per cent more powerful than T. N. T. and more easily detonated. It is more sensitive to shock than T. N. T., but not sufficiently so to be dangerous. It is stable at all ordinary temperatures if manufactured properly. It melts at about 130° C., and explodes at 186° C. It is a very excellent explosive for booster charges, but it is expensive to manufacture, and is sometimes too sensitive for a projectile filler. Tetryl is made by the action of nitric and sulphuric acid on dimethylaniline. Aniline is heated with alcohol under pressure in autoclaves, in the presence of sulphuric acid, to form dimethylaniline. After nitration, the tetryl separates out as a crystalline powder, and is then filtered, washed, and dried in trays in dry houses.

Care in handling.

33. The same precautions are followed in handling tetryl as when handling other high explosives. Special care is required in manufacture and loading, due to the dangers of tetryl poisoning.

T. N. A.

34. A similar explosive, derived from aniline, is tetranitroaniline. It is more powerful than tetryl and less sensitive to shock. It is rather poisonous and has a tendency to hydrolyse. It is expensive to manufacture and has not come into common use, but may be used in place of tetryl as a booster material. Its stability has not been wholly established.

Amatol.

35. The above-mentioned explosives are all aromatic nitrocompounds. During the World War, on account of the shortage of toluol, it became necessary to adopt a mixture for padding out the T. N. T., using inorganic compounds. Ammonium nitrate has been used for many years as an ingredient in mine explosives.

Amatol is made by melting T. N. T. and incorporating ammonium nitrate, making a 50-50 or an 80-20 mixture. This explosive may be met with in certain projectiles or bombs obtained from the United States Army.

Nitrostarch.

36. Nitrostarch came into use during the World War for the same reason as amatol. It is never used alone, but always mixed with some substance such as ammonium nitrate, or sodium nitrate, and diphenylamine. In its manufacture, starch is fed slowly into a mixture of nitric acid and sulphuric acid, which is agitated. The nitrostarch formed is separated from the spent acids, washed and centrifuged, and then dried. It is then mixed with ammonium nitrate and stablizers, and packed in hand and rifle grenades and trench mortar projectiles. The amount of nitrostarch varies in different compounds. When 40 per cent is used, the mixture is called Trojan powder. Grenite contains about 95 per cent nitrostarch and is used in grenades only. These powders are highly inflammable and more sensitive than T. N. T. Improvements in manufacture have increased the stability of these explosives, but they must be stowed in dry places at moderate temperatures. Their stability under stowage conditions, afloat for extended periods, has not been established. Nitrostarch explosives are hygroscopic.

Nitroglycerine.

37. Nitroglycerine has not been found suitable as a military high explosive, due to its great sensitivity. It has, however, been used to a great extent mixed with other substances to form dynamite for commercial uses

Chapter IX.

DETONATING SUBSTANCES.

General.

1. When black powder came into use as an explosive, it was first ignited by the direct action of a flame and later by means of a flint and steel. These methods were not safe and sure, so improvements were sought. The discovery of fulminate of mercury and the various characteristics of this material made it readily available for use in a cap for the purpose of ignition. Fulminate of mercury can be detonated by a blow and goes off with great heat and some flame. It is a very powerful explosive, however, and, for the purpose of igniting black powder, is used in very small quantities. If used alone, it explodes with great violence, hence other substances are mixed with it to diminish the violence and to increase the heat and length of flame. The primer cap of the present time usually contains fulminate of mercury, chlorate of potassium, and sulphate of antimony, and, as fitted in a primer, when struck or heated, fires a small charge of fine black powder which ignites the powder charge. Primers are discussed in chapter 13.

Ignition of smokeless powder.

2. In the discussion of smokeless powder, it was pointed out that the powder grains burn from the surface inward in parallel layers. To ignite a grain it is necessary to apply a flame for a long enough period to cause a chemical transformation and oxidation on the surface, whereupon the grain begins to burn and the action will continue until the grain is consumed. The primer as used for black powder alone will not ignite smokeless powder directly as it does not give a sufficient volume of flame and heat, so it is necessary to introduce another agent to prolong the primer flame until the smokeless powder starts to burn. Black powder is found to be the most suitable for this purpose. It is introduced as a part of the primer in case ammunition, or as the ignition charge in bag gun ammunition. Getting the proper effect from the ignition charge is very important, as variations will have an appreciable effect on muzzle velocities and pressures. From experimental work certain rules for assigning and distributing the weight of the ignition charge have been adopted and these govern the present practice.

Projectile fillers.

3. When black powder was in general use as a projectile filler, the fuses operated on the same principle as the primers. A percussion cap, either directly or through the agency of a time train, fired a small priming charge of black powder which set off the burster charge. Such fuses are called ignition fuses, as they set off the burster charge by flame. With the introduction of high explosives, this method of causing a projectile to burst was found impracticable. Investigation showed that fulminate of mercury would cause dry guncotton to explode. It was found that when dry guncotton exploded in proximity to wet guncotton it caused the latter to detonate.

These discoveries made guncotton a valuable high explosive for torpedo war heads and mines, but it was not suitable for use as the burster charge of projectiles. As fulminate of mercury could be made to explode other nitrocompounds, and as some of them were suitable for use as explosive charges of projectiles, they were adopted for this use. However, ignition fuses were not suitable for exploding high explosives, and it became necessary to conduct a series of investigations of the phenomena connected with the exploding of high-explosive compounds. The details of the fuses used with high explosives are set forth in chapter 13.

Detonation.

4. To get the full explosive effect from a high explosive, it is necessary to have the substance change in a very short space of time into gaseous products. This almost instantaneous transformation is called a detonation. To obtain a detonation a very sudden and intense blow is necessary. Ignition of a part of the mass of a high explosive will not cause all high explosives to detonate. There is a class of these substances which, however, when ignited will burn for a very short space of time and then detonate. All high explosives will detonate under the shock of another detonating substance placed close to them under proper conditions. These properties of high explosives are taken advantage of in adapting them for military uses. The substances which will detonate by the application of ordinary means, such as heat, impact, or friction, and will impart a percussion blow of such character as to detonate those high explosives which can not be detonated directly by the same ordinary means are called initiators or detonating substances. Among such may be considered fulminate of mercury, silver and lead azide, nitrogen sulphide, and others.

Theory of detonation.

5. After the discovery of high explosives, it was realized that the detonation was propagated as a wave, similar to sound waves, and that the velocity of this wave could be measured. Investigation showed that smokeless powder burned, even under high pressures, at a velocity of less than a few meters per second; black powder at less than 300 meters per second; whereas high explosives detonated at velocities up to several thousand meters per second. A detonation is effected when the wave of detonation proceeds through the mass of unaltered explosive with a velocity of several thousand meters per second, changing the material as it proceeds into the transformed products of explosion. It was found that fulminate of mercury, when heated to the ignition point, burned for a short space of time at a low velocity, which instantly increased to detonation at about 4,000 meters per second. This transition from burning to detonation is so rapid that it can not be followed, but if a sufficient quantity is available in the presence of another high explosive, the latter will also detonate. The action of the second explosive in detonating is accounted for either by wave synchronization, or by the enormous pressure created by the initiator. It has been shown that very small quantities of fulminate of mercury will cause certain high explosives to detonate readily, whereas other initiators require larger quantities to obtain the same results. From experiments along this line the theory has been deduced that the wave of detonation in the fulminate and that in the high explosive synchronize; hence, very

small quantities cause a detonation. The other theory attributes the effect of the initiator to the development of an enormous instantaneous pressure, this pressure being caused by the kinetic energy of the molecules, so that the velocity of detonation, the volume of the gas, and the heat of the explosion affect the results. Another theory accounts for the action by the production of a very intense shock. Whatever the theory, "the explosion of a detonating substance gives rise to local action in the form of a violent blow or pressure due to the extremely rapid transformation of a solid of high density into a large volume of gas at a very high temperature, and that this property makes it so effective as an initiator of detonation in other explosives" ("*Colver High Explosives,*" footnote). The capacity to initiate detonation depends very little on the sensitivity either to heat or shock, but for use the detonating substances must be sensitive enough to start the action by simple means, such as firing locks and exploders.

Boosters.

6. High explosives are sensitive to the action of a detonating substance to a greater or less degree. Picric acid, tetryl, or T. N. T., are more sensitive than ammonium picrate. Consequently, just as it is necessary to use black powder between a fulminate cap and a smokeless powder charge, so it is desirable, to obtain the best results, to use a secondary detonating substance between the initiator and the main charge of high explosive. With certain explosives, such as wet gun cotton, cast T. N. T., and others when compressed to a high density, this secondary detonating substance is a necessity, as the initiator will not explode the main charge directly. Detonators are copper tubes filled with detonating substance, usually fulminate of mercury. An improvement has been made by reducing the amount of fulminate and replacing that removed with T. N. T., tetryl, T. N. A., or trinitrobenzene. With this latter change the same effect as a detonator is obtained but greater safety in handling results. The secondary, or intermediate detonating substance, is called the "booster." A compound is used which is too insensitive to be detonated directly but is sensitive enough to be detonated by the initiator and to pass along the effects to the main charge. Hence, we have boosters in torpedo war heads (formerly called torpedo war-head primers), mines, depth charges, bombs, and in detonator fuzes for projectiles. The relative weights of initiators and boosters are arranged to get the best detonation from the main charge.

Fulminate of mercury.

7. Fulminate of mercury was discovered in 1799, and was first used practically for the manufacture of percussion caps in 1815. The sensitivity is so great that accidents, especially in manufacture, are numerous and frequent attempts have been made to find a siutable substitute. However, no substance has to date replaced fulminate of mercury for general use, as caps made with it are more reliable, sensitive, and quick in action than nonfulminate caps. Nonfulminate caps have been successfully used in small arms.

Manufacture.

8. Fulminate of mercury is made by mixing a solution of mercury with alcohol in the presence of an excess of nitric acid. Due to the dangers in manufacture, it is usually prepared on a small scale. A charge of pure mercury is dissolved in nitric acid. This acid solution is then poured into a container in which there is a charge of almost pure alcohol. A violent action results which, when completed, leaves the solid crystalline fulminate in the liquid. The charge is then screened, washed, all impurities removed, and the fulminate of mercury drained and packed in bags in water. When required for use the fulminate is dried.

Characteristics.

9. When pure it is a fine, yellowish-white crystalline powder. The gray color of the commercial fulminate is due to small particles of unconverted mercury. When dry it is very sensitive and is readily detonated by percussion, friction, flame or spark, electric spark, or by contact with sulphuric or nitric acid. When moistened with from 5 to 30 per cent of water, its sensitivity is much reduced, although the explosion of a quantity of dry fulminate in contact with wet fulminate will explode the latter even if completely immersed in water. The sensitivity is increased with the size of the crystals and with heat, as it is more sensitive when hot than cold.

Storage.

10. Fulminate of mercury is unaffected by variations in ordinary storage temperatures. Its ignition point is over 150° C. Its explosive qualities are adversely affected by moisture, however, and no effort should be spared to keep all fulminate detonators and ammunition containing fulminate caps dry. If unconfined, it burns fiercely, and when only slightly confined it detonates. When dry it reacts very slightly with metals, but if any free mercury is present it will form an amalgam with brass or copper, this action being increased with moisture.

Value as initiator.

11. The explosive action is very sudden and violent, generating high pressures. It can not be compared with other high explosives by the usual tests, as its velocity of detonation is much less than other high explosives and the total heat units per gram are less. Its property of igniting, then rapidly detonating, gives a powerful disrupting effect and makes it useful for initiating detonations; consequently, it is used only for this purpose, either alone or mixed with other substances.

Caps for small arms.

12. Percussion caps for small arms and primers contain fulminate of mercury. Potassium chlorate is added to increase the heat of explosion by its oxidizing action. Sulphide of antimony is added to prolong the action of the cap as it produces a long flame. Powdered glass has been added to increase the sensitivity.

Azides.

13. Certain substances, recently introduced, have been considered as substitutes for fulminate of mercury. They are silver, lead, sodium, and other azides, of which lead azide or lead hydronitride seems to be the most promising. These substances are less sensitive if the crystals are small, have more energy, and are stable and durable. Lead azide also has the property of increased brisance with increased pressure. However, they are less brisant than fulminates, but this may be overcome by mixing azides and fulminates. They have not come into general use as initiators. Nitrogen sulphide and other similar substances are not stable enough and are too sensitive for use.

Chapter X.

PROJECTILES.

1. The word "projectile" is the standard practice of the Bureau of Ordnance and the word "shell" is not standard, and should not appear in correspondence, specifications, or drawings. **General.**

2. The form adopted for the front end of a projectile is that known as the *ogive*, which is generated by the revolution of the arc of a circle around a chord, the chord being the axis of the projectile, the versine of the arc being the semidiameter of the projectile, and the sine of the arc being the length of the ogive. The shape of the ogive is generally expressed by stating its radius in terms of calibers. At the present time the majority of the United States naval projectiles have ogivals of 7 calibers radius. Frequently the ogival shape is secured by the combination of several arcs of different radii. In recent years, also, the ogival shape has been occasionally abandoned in favor of a conical shape, or partially conical shape, as that form lends itself with greater facility to mechanical processes. **Form of forward end.**

3. With proper rotation, it is desirable to keep the center of gravity of the projectile to the rear of, or in the immediate vicinity of, the center of form, particularly in long projectiles. As piercing projectiles require a blunt and solid nose for penetrative ability the amount of metal in the forward end must be great. Also a fine forward form is conducive to long range. To reconcile these two opposing yet necessary qualities it has been advantageous to adopt light nose pieces, wind shields, or false ogives, all of which names are more or less synonymous.

4. Practically all United States naval projectiles have the corner of the base turned to a small radius, varying from 0.375 inch for large projectiles down to a mere touch of the file on the corner of the small ones. **Form of after end.**

5. Frequent firing have, however, shown that increases in range can be secured by shaping the base to a finer form than a mere rounding of the corner. This scheme is generally referred to by naval ordnance engineers as *boat-tailing*, an expressive but peculiar term. But the deterrent fact is that, while comparatively small increases in range may be secured, they are generally accompanied by loss of accuracy.

6. It has finally been determined, however, that a high velocity (2,500 to 3,000, foot-seconds) projectile will give slight increase in range without loss of accuracy if the rear end is coned between 5° and 8° for a distance of from approximately 0.25 to 0.75 caliber, the angle of the cone between those limits depending on the velocity and form of ogive.

7. In cartridge-case projectiles another factor is added in connection with the form of the after end, for in such projectiles that portion must be kept cylindrical for a considerable length in order to provide a proper bearing for the cartridge case.

Form of body.

8. Between the ends, whatever their shape and length, is the cylindrical portion or body of the projectile. At the after end of the body is the rotating band or bands, and at the forward end is the bourrelet. Between these two parts the diameter of the body is slightly reduced, in order to provide a generous clearance from the bore of the gun. It is the support and bearing provided by the band and bourrelet which steady the projectile in its travel through the gun and it is quite evident, therefore, that there must be a reasonable distance between them, else too heavy a duty will be demanded of them in preventing wabbling. There is no fixed rule as to what this distance must be, but designers generally allow about one caliber for minor-caliber projectiles and increase the distance gradually up to about 1.4 calibers in major-caliber projectiles.

Exterior finish.

9. As a general rule projectiles are given, except on the bourrelet, only a rough machine finish; that is, one which, while smooth to the eye from a distance of, say, 8 or 10 feet, shows on closer inspection the marks of the turning tools. It is a popular fallacy that a smooth finish is conducive to accuracy. A very complete experimental firing was carried out some years ago in which a series of 14-inch target and armor-piercing projectiles were fired at a standard elevation, velocity, and projectile weight, half of the projectiles being carefully ground and polished to a fine finish, while the other half were left the usual finish. The difference in finish appeared to have negligible effect on the dispersion; in fact, those projectiles with the rough or service finish gave a smaller dispersion than did those with the polish.

Weight.

10. Within reasonable limits projectiles can be given various weights for a given gun. The relation between weight of projectile and powder charge, muzzle velocity, and pressure is a part of interior ballistics. The weight of all United States naval projectiles follow a definite system of apportionment, which, stated in calibers, is as follows:

$$w=\frac{d^3}{2},$$

where

w = approximate weight of projectile in pounds.
d = caliber of gun in inches.

The weight of projectile per square inch of bore is called the *sectional density* of the projectile and is represented by the following expression:

$$S.D.=\frac{W}{A},$$

where

S.D. = sectional density.
W = weight of projectile in pounds.
A = area of bore, including grooves, in square inches.

This figure has frequent application in gun and projectile design. The sectional density varies from 0.635 for a 1-pounder up to 10.44 for a 16-inch, averaging approximatelty 0.6 of the caliber.

The distribution of the weight in a projectile is a matter of considerable importance. As a general rule, the center of gravity should be in the longitudinal axis and close to or abaft the center of form. Slight variations in the location of the center of gravity, with respect to the center of form, have negligible effect on the dispersion.

The bourrelet.

11. The bourrelet is, as was stated previously, the forward bearing of the projectile. Its surface is generally ground to a fine finish in order to reduce friction and to prevent wear of the lands of the gun. This bearing surface is usually about one-sixth caliber in width; that is, longitudinally with the projectile. Some few small projectiles have no real bourrelet, the entire body of the projectile forward of the band replacing it.

12. The bore of a gun becomes "coppered" after repeated firing with a fine deposit of copper from the projectiles' rotating band. And frequently, also, the liner in a gun becomes slightly crumpled or ridged after repeated firing, particularly in wake of internal shoulders. A certain clearance must, therefore, be provided between the bourrelet and the lands. The standard United States Navy practice is to make the bourrelet diameter 0.015 inch smaller than the bore of the gun. A minus manufacturing tolerance is added to this diameter of another 0.015 inch, so that the average clearance is about 0.012 inch. Clearances of 0.05 inch have practically no effect on the dispersion, but it is reasonable to assume that unnecessary clearance can have at least no beneficial action, and may have an injurious effect on the lands, due to the blows of possible wabbling. It is quite apparent, also, that the less the clearance the more accurate will be the initial direction of the trajectory.

13. In a few instances a centering band of copper replaces the bourrelet, but as yet this system has not had wide application. It is generally conceded to be inapplicable to armor-piercing projectiles, as the "score" would weaken the projectile at a vital locality.

The rotating band.

14. The rotating or rotation band has three specific functions—to seal the bore, to steady and center the rear end of the projectile, and to rotate the projectile. It is also utilized to prevent overramming in worn guns and to hold the projectile in place during loading and elevating for firing. In addition to these functions the band has considerable effect on the range, dispersion, muzzle velocity, and life of the gun.

15. Rotating bands are made of commercially pure copper for all minor and medium caliber projectiles, and of cupro-nickel alloy containing 2.5 per cent nickel for major-caliber projectiles, the nickel being added to secure greater strength. In 1921, however, the bureau abandoned the use of cupro-nickel, and in future all bands will be made of copper.

16. As a general rule rotating bands are about one-third caliber in width. In some instances, particularly abroad, the width of a band is kept down to a maximum of about 1.5 to 2 inches, and where a greater strength is necessary two separate bands, separated by a short distance, are provided. This system has considerable merit.

17. The *band* is secured in a *score* cut in the projectile body, there being a dovetail on each edge to assist in overcoming centrifugal force, and either waved ridges, longitudinal nicks, or knurling in the bottom of the score to insure against slipping during acceleration. The band is made as a ring of slightly greater internal diameter than that of the body and is slipped over the score, while hot, and pressed radially into place in a powerful hydraulic press called a "banding press."

18. The forward edge of the band is slightly conical and fits into a correspondingly coned seat at the origin of rifling. The central portion of the band is generally cylindrical and of a slightly greater diameter than the diameter of the bore, including grooves. An expression often used to obtain the diameter is "$\mathbf{D} = \mathbf{C} + \mathbf{2p} + \mathbf{.02}$" where **C** is the caliber of the gun and **p** the depth of the grooves. It will be observed that on the rear part of practically all bands is a raised lip. This lip serves the purpose of insuring a good gas check and at the same time, because of its considerably greater diameter, preventing overramming in a worn or eroded gun.

19. In order to insure a tight joint, especially in eroded guns, the diameter of the cylindrical portion of the band is generally a few thousandths of an inch greater than the diameter of the bore across grooves. It is clearly evident, however, that any excess metal in the band will be pressed or wiped back toward the base of the projectile, this being more pronounced in wake of the lands. Should this excess metal be of sufficient quantity it will form a scalloped skirt extending abaft the band score. Now at the instant that this skirt clears the muzzle there will be a rush of gas past it, which, aided possibly by centrifugal force, may turn this skirt out radially at a considerable angle. This is called *fringing*, and a pronounced fringe can have a material effect on the range and dispersion, the effect being greatest on minor and medium caliber projectiles.

20. The successful design must not only provide sufficient metal in the band to secure the desired performance but must also insure against fringing. Grooves or "cannelures" are placed in the middle portion of large bands, for the purpose of allowing space for this excess copper, and a large groove is also frequently provided abaft the lip to take this excess copper.

Under water attack.

21. When an ogival-headed projectile, traveling in air, strikes water, it deviates from its trajectory in a violent and uncertain manner. At small angles of fall it tips up, runs parallel with the surface for a short distance, and then, if it still has sufficient velocity, emerges and again takes to the air. This is called a *ricochet*. At greater angles of fall it is liable to deviate in any irregular direction.

22. The desirability of the attack of submarines by gunfire from surface or aircraft has resulted in the development of projectiles which maintain their trajectory, upon entering water, with reasonable accuracy. In the projectiles the ogival form is abandoned and a square head is substituted. Such projectiles are called, in our Navy, "flat-nose" projectiles and elsewhere are referred to as "diving shell."

23. The retardation of the translational velocity of these projectiles in both, air and water is excessive, but such a sacrifice has to be made in order to secure accuracy upon and after water impact. Interesting proposals have been made to fit flat-nose projectiles with thin wind shields or false ogives which will collapse and be wrenched adrift upon impact with water, thereby preserving both good flight in the air and underwater accuracy.

Classification.

24. Projectiles used in the United States Navy are divided into 10 classes, as follows:

(*a*) *Armor-piercing* (*A. P.*).—These projectiles are subjected to a test against a face-hardened plate 1 caliber in thickness.

(*b*) *Common.*—These projectiles are subjected to a test against plates one-third to one-half a caliber in thickness.

(*c*) *Class B.*—A class B projectile is one that has a minimum wall thickness consistent with the setback in the gun, and which permits a maximum bursting charge. The ogive is in general similar to the ogive of a common projectile. The projectile is not subjected to a plate test.

(*d*) *Shrapnel.*—A modern shrapnel is a projectile containing shrapnel balls which are expelled from the shrapnel case by means of a small charge of explosive, the case remaining intact.

(*e*) *Flat nose and cup nose.*—Flat and cup nose projectiles are designed with thin walls and maximum bursting charges and are in this respect similar to class B projectiles. The noses of the projectiles are flat or cup shaped which prevent ricochets of the projectiles upon striking water. Both are primarily designed for use against submarines.

(*f*) *Illuminating.*—An illuminating projectile is one that discharges an illuminating element.

(*g*) *Smoke, gas, etc.*—These are special projectiles containing a smoke, gas, etc., producing element.

Manufacture of armor-piercing projectiles.

(*h*) *Tracer.*—These projectiles are designed *solely* to leave visible traces in the daytime, and do not have bursting charges. They are a separate class from other projectiles which, when required, may be fitted with tracers.

(*i*) *Target.*—A target projectile is one that represents ballistically, as far as flight is concerned, another projectile, but which contains no explosive. Target projectiles are used for ranging and target practice.

(*j*) *Proof shot.*—Proof shot are slugs, the base and bourrelet dimensions of which are the same as those of projectiles of the same caliber. They give the same interior ballistics as the projectiles they represent, but their exterior ballistics are different. Proof shot are used for testing guns and powder, and also for spotting practice on board ship.

The words "high explosive" and "high capacity," etc., are not to be used in designating types of projectiles.

25. Open-hearth steels—acid, basic, and electric—are used for armor-piercing projectiles, but the melting is given far greater care than is received by the average commercial steel. The ingots are cast nose down in iron molds in order to chill them rapidly to prevent piping and injurious segregation.

26. There are two general systems of forging. In one the ingot is cast of greater diameter than the finished projectile, and is forged down, being lengthened in the process, under a press or hammer, and in this process the cavity is bored out. In the other process the ingot is of smaller diameter than the finished projectile, is upset in a die under a press to the proper diameter, and its base is then pierced by a punch to form the cavity, the rear walls of the body being somewhat extruded. In the first process mentioned the grain or fiber of the steel is longitudinal whereas in the other process it is transverse.

27. The rough forgings are then annealed, after which they are rough machined nearly to size. The next step is a series of heatings and quenchings in oil and hot water for the purpose of refining and fibering the grain structure. After this treatment the forging is turned to exterior and interior dimensions, allowance being made for the fitting of base plug and finishing of band score and bourrelet.

28. The next step is the hardening, which is accomplished by a graduated heating beginning with the point followed by a complete quench in agitated cold water. This puts the entire projectile in an exceedingly hard condition. The heating for this treatment is generally accomplished in a bath of molten lead, such procedure being conducive to accurate control of both temperature and position of application of heat. After this the base of the projectile is heated to a lower temperature than was used for quenching and upon withdrawal from the bath or furnace is suspended nose down and immersed up to the bourrelet in agitated cold water. This procedure draws or tempers the rear portion while preserving the hardness in the head. The result is an exceedingly hard head to the rear of which the hardness gradually decreases with increase in toughness. The hard head is to effect the smashing of the plate's face while the tough rear is to support the head and stand the breaking strain of angle impact.

29. Finally, the projectile is sand blasted, the band score is finished and the band pressed into place, the cap and wind shield is put on, the bourrelet is ground, the band is turned to size, and the base plug fitted.

30. The cap follows, in general, the same methods of manufacture and treatment as are applied to the projectile, although, of course, no special ingot is made for it. After forging it is annealed and rough turned, is then fibered, then finish machined, except threading for the wind shield, then decrementally hardened and finally finish turned and threaded and installed. Caps are made of the same kind of steel as are the projectile bodies, except that the carbon, nickel, and chromium are not so high.

31. Caps are secured to the projectile by several methods. The one most commonly used consists in peening the skirt of the cap into notches cut in the ogive of the projectile. Another method consists in soldering the cap to the ogive with a special low melting point solder. Such a solder is required to prevent the heat necessary for soldering from drawing the temper of the ogive.

32. Caps should be held securely in place, and it is quite probable that their efficiency on oblique impact is materially affected by the security of the bond. The notches in the ogive are certainly no source of strength. The use of solder is therefore looked upon with favor by many ordnance engineers.

33. It occasionally happens that caps become loosened by rough handling. Such projectiles should be returned to an ammunition depot for recapping.

34. The wind shield is made of either cast iron or forged mild steel, and has no special strength other than that necessary to prevent destruction during handling and setback. Wind shields are generally screwed on the cap, and frequently the thread is cut on a tapered surface. After screwing home they are "set" by a center punch at the joint. They sometimes become loose in handling and in that event they should be tightened and reset.

35. Base plugs are simply ordinary good quality nickel-steel. The only requirement is that their longitudinal axis should be normal to the longitudinal axis of the original ingot, a precaution taken to insure the maximum strength against shear or collapse under the chamber pressure of the gun, and to prevent piping or porosity from leading flame or gases into the bursting charge. This latter precaution is taken with *all* projectile base plugs and will not be referred to again under other projectiles.

36. The steel for armor-piercing projectiles is the finest quality, nickel-chrome steel. Due to the comparatively small mass and more convenient size the carbon can be carried much higher than is possible in armor manufacture. For instance, we find the carbon content as high as 0.75 per cent. Similarly the chromium can be carried a little higher and we find the chromium content as high as 2.60 per cent. The nickel runs about the same as for armor.

The action of the cap.

37. Various theories have been advanced as to the reason for the increase in penetration secured by the application of the cap. The simplest, and perhaps the most reasonable, is that the cap acts to break down the initial strength of the plate, allowing the nose to reach an already strained surface and then provides powerful circumferential support to the point and nose as they begin to penetrate the hard face, maintaining the support until they are well into the plate. This theory is supported by the fact that an uncapped projectile requires less initial velocity to penetrate a nonface-hardened plate than does a capped projectile, as experiment has shown, the slight decrease being ascribed to the adding of the thickness of the cap to that of the plate. In comparing capped and uncapped projectiles against face-hardened plate, recent experiments with 8-inch projectiles have shown that equal penetration can be secured when the energies are as about 5 to 9.

38. And finally the cap has the effect of increasing the *biting angle;* that is to say, a capped projectile will "bite" or fail to glance off at greater angles of obliquity than will the same projectile without a cap. This is due to the greater bluntness of the front end of the cap.

Form of internal ogive.

39. The shape of the ogive of the projectile itself has considerable effect on the efficiency of the projectile. The curvature of the ogive was increased to about 2.5

calibers because of the desire to reduce air resistance, and this curvature was retained under the cap after its adoption. Shorter curvature is desirable, however, to secure a shorter projectile, and the modern tendency is to fix the ogive radius betwen 1.5 and 2 calibers.

Common and class B projectiles.

40. The development of the common and class B projectile followed logical channels, being based on the attack on unarmed vessels, the upper works of armored vessels, earthworks, and fortifications.

41. As a general rule the design and selection of materials of these projectiles is predicated, in so far as is consistent with efficient operation, on *cheapness* and *quantity production.* In fact, the coordination between design and quantity production is of almost vital importance. These considerations led to the selection of plain 0.45 per cent to 0.60 per cent carbon basic open-hearth steel, and the adoption of a design which reduces the number of forging and machining operations to a minimum. In designs requiring the maximum attainable weight of bursting charge, or calling for peculiar interior arrangements, greater strength per unit of area will probably be required, in which case a higher carbon or even a nickel-steel may be necessary.

42. Methods of fabrication differ with the caliber and type. In large calibers each projectile is made from a separate ingot, while in medium calibers large ingots are "cogged down" in a rolling mill to billets of round, square, or polygonal section and then cut or broken to proper length. The ends of these blanks are usually inspected to eliminate those which contain piping or injurious segregation.

43. Considering major and medium caliber projectiles, and the ingots or billets made for them, as mentioned above, fabrication continues, in general, as follows:

44. The projectile blank is heated, placed in a die approximating the exterior contour, nose down, but of excess diameter, and then pressed under the plunger of a hydraulic press, thus forming the ogive. A piercing die or plunger of slightly less diameter than the cavity is then forced into it, which forms the cavity. These two steps can be done with one heating.

45. In some projectiles this is the only forging required, but generally the extrusion performed by the piercing die is insufficient to make the cavity long enough. In this case, which is quite general, the forging or blank is reheated and placed in a draw bench, the nose being placed in a die containing a circular hole slightly larger than the finished diameter, and it is then forced through this drawing die by a hydraulically operated plunger which is inserted in the already partially formed cavity. This drawing process forces the sides back over the plunger, thus extending the blank to the required length. In some cases more than one draw is required, and this is generally performed in one heat by forcing the forging through several rings or dies in succession in the same draw bench. The method just described applies, of course, to open-base projectiles. Where the base is to be solid and the nose is to be open the same general process is followed, except that the projectile is worked from the base instead of from the nose.

46. The blank is then generally annealed, or normalized, and if high physical properties are required, it may be heat-treated to secure them. It is then passed to the machine shop for finishing.

47. The finishing consists in turning and boring to the correct dimensions and tolerances, banding, fitting the plug, painting the interior of the cavity, and inspecting and stamping for shipment. As a general rule all surfaces are finish machined except as noted below. Many efforts have been made to omit the machining of the cavity, but the forge finish is not satisfactory because the forging temperature is so high that a rough and scaly surface results.

48. Some projectiles are fitted with heavy nose or base plugs, others have smaller adapters to carry the fuse, and others may be designed to receive the fuse itself. In most of these classes the cavity is always of larger diameter than is the hole for these fittings. This condition is met in two ways.

49. Where the hole is large and the amount of metal to be removed from the rough forged cavity is small, or where the projectile is completely heat-treated, the interior is finished in a boring machine or lathe, using a tool on the end of a bar which is inserted in the hole. This bar is swung on a pivot in order that the tool can be made to follow the desired contour of the interior.

50. Where the cavity is large and entails the removal of considerable metal, or where the forward or after fuse plug hole is so small as to render machining impracticable, an entirely different process called *nosing-in* or *basing-in*, as the case requires, is employed. Here the inner portion of the cavity is machined to size while the outer portion of the cavity is machined to a cylindrical or nearly cylindrical size, any shoulders or seats being also partially machined. The exterior surface of the projectile, in the wake of that portion of the cavity which is to be closed in, is then turned to the reverse curvature of the cavity, or, in other words, the approximate contours of the cavity and outside are exchanged and reversed. That part of the projectile which is to be closed in is then carefully heated in a nonoxidizing flame, and is then either forced into a die, under hydraulic pressure, which is cut to the proper exterior shape, or is pressed into shape under radial pressure. As was stated above, this process can be applied to either the ogive or the base.

51. This operation can be so satisfactorily performed that no machine workis necessary on the closed-in portion except the fitting of screw threads and gas-tight seats.

52. It is generally customary to select tensile-test specimens from heats or lots after all forging or heating is completed, in order to insure that uniform and satisfactory results are being secured.

53. The processes referred to above apply to practically all kinds of projectiles, except armor-piercing and minor-caliber projectiles.

54. Minor-caliber projectiles are generally machined from round rolled bars, the forging to shape with final finishing being more expensive than complete machining.

55. Base plugs, fuse-hole plugs, adapters, and the miscellaneous interior parts of shrapnel, illuminating projectiles, gas and smoke projectiles, etc., are manufactured by the various drop-forging, drawing, and machining processes covered in textbooks on mechanical processes.

Special projectiles: shrapnel.

56. This type of projectile is designed for use against personnel and its only naval use is, therefore, in connection with landing parties, bombardment of fortifications, and attack of aircraft. It is interesting to know that the name is derived from the inventor who brought it out in Europe in 1784.

57. The most common form of shrapnel consists of a case in the rear of which is a black-powder bursting charge, connected to a nose fuse by a central explosion tube around which is packed a large number of lead (88 per cent) antimony (12 per cent) balls held securely in place by a matrix of hot-poured rosin. When the fuse acts the balls are expelled forward by the bursting charge and scattered in a cone-shaped cloud. Shrapnel are, however, frequently given other features. For instance, a high explosive may replace the rosin to increase the violence of the burst and the area or damage; or there may be a heavy head with a high-explosive burster and suitable fuse in order to follow the cloud of balls with a secondary explosion. And finally the balls may be replaced by small hollow open-ended cylinders in which phosphorus or other incendiary compound is packed, the object of this design being to add to the local explosion and distribution of missiles the probability of creating a conflagration. This design is particularly valuable against aircraft of all descriptions, especially those which employ hydrogen.

Illuminating projectiles.

58. In this type we have a case, similar to a shrapnel case, with a very small burster in the front end just abaft the fuse, and an interior assembly of a star or candle with parachutes, and a very lightly held base plug. The explosion of the burster, or as it should be called, the expelling charge, forces out the base and the interior assembly. It is quite desirable to expel the assembly with considerable velocity, at least 300 to 400 foot-seconds relative to the case, in order that it will have as small a velocity, in space, as is possible. It would be preferable to have the assembly expelled at the same velocity as the case is traveling, but at present this is not possible. The star or candle is a steel container in which is packed, under heavy pressure, an illuminating compound in which magnesium is an important constituent. The explosion of the expeller ignites the candle or star. The closed end of the star container is attached to a wire rope which carries a series of parachutes, the number depending on the weight of the star. These parachutes are carefully folded and they, and the wire, are so rolled that, upon expulsion, they open or come into action in succession beginning with the one nearest the star. The parachute nearest the star is quite small, only 4½ inches in diameter for a 3-inch projectile, and they increase in size until for a 5-inch projectile, for instance, the last parachute is about 3½ feet in diameter. The small parachutes are called retarding parachutes and the last and largest the sustaining parachute. From this description the action of the assembly upon ejection is easily seen. The fast-moving, heavy and burning star is gradually slowed down by the retarding parachutes, the opening of successive parachutes increasing the effective area and thereby maintaining a more or less constant retarding force, until by the time the sustaining parachute unfolds it can open without danger of being torn to ribbons. This action is similar to that of a recoil brake. The wire for a 3-inch projectile is about 15 feet long and carries three parachutes, while in a 5-inch projectile the line is about 40 feet long and carries seven parachutes. The entire assembly gradually tails vertically and sinks earthward with comparatively slow speed, the light of the star being thrown downward. As there is no need, with illuminating projectiles, for either great accuracy or a flat trajectory, fineness of exterior form is sacrificed to secure the maximum size and weight of star.

Smoke and gas projectiles.

59. These, when specially designed for the purpose, are quite similar to any high explosive of class B projectile so far as the projectile itself is concerned, the difference lying in the kind of fuse, contents, and method of loading.

Target projectiles.

60. Economy requires that target projectiles be made of the least expensive materials. They are, therefore, made of cast iron. A good grade of cast iron, and efficient methods of casting are necessary, however, to insure that the setback and centrifugal force do not cause fracture, either in the gun or in initial flight. They are so designed that they are similar to their prototypes in exterior shape, weight, and balance. No economy can be secured in the rotating band, as it must function in the normal way.

Proof shot.

61. Proof shot, sometimes called "slugs," are solid cast-iron shot with a square forward end. From the forward edge of the rotating band to the rear, they are identical in shape with the standard projectile of their caliber, but their only other similarity is their weight and bourrelet diameter. As a result of this design their behavior *in the gun* or exterior ballistics is similar to, while their flight is much shorter than, that of the standard projectile. They are used for proving-ground work and spotting practices.

Marker projectiles.

62. A projectile similar to an illuminating projectile is fitted with a buoy in place of the star and parachute assembly and a water-impact fuse. The buoy carries a burning charge, principally compounds of phosphorus, which are ignited by the fuse, but which can not be put out by water. The burst expels this buoy, thus leaving a comparatively permanent mark of the position of the fall. This projectile is to indicate the position of hostile submarines to pursuing or hunting vessels.

Line-carrying projectiles.

63. These are simply loose-fitting slugs which carry a rod extending to the muzzle with an eye in the end, to whch is attached a light cord. The projectile turns around immediately after firing, and is held to its trajectory by the strain of the trailing cord. The cord is coiled down on deck and, after the projectile has passed over the target, a heavier line is bent to it and with succeeding heavier lines a hawser can finally be run. A range of about 350 yards can be secured in a 3-pounder saluting gun.

64. The following table shows the marks, modifications, and characteristics of all projectiles used in the United States Navy, with the guns in which they can be fired.

CHARACTERISTICS OF PROJECTILES.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
18-inch.	Target, type A..	72300	81.0±.15, 4.5 cal.	162.0, 9 cal...	[1] 17.977+.000−.007	17.94+.00−.04
	Target, type B..	74911	72.0±.15, 4 cal.	126.0, 7 cal....	[1] 17.977+.000−.007	17.94+.00−.04
	Target, type C..	74913	63.0±.15, 3.5 cal.	126.63, 7 cal..	[1] 17.977+.000−.007	17.94+.00−.04
16-inch.	A. P., Mk. II–1..	50926	56.82±.15....	112.56, 7 cal..	15.985+.000−.005	15.94±.02
	A. P., Mk. II–2..	58839	56.54±.15....	.....do........	15.977+.000−.007	15.94+.00−.04
	A. P., Mk. II–3..	59438	56.79±.15....	.....do........	15.977+.000−.007	15.94±.02
	A. P., Mk. II–4..	59489	56.54±.15....	.....do........	15.977+.000−.007	15.94±.02
	A. P., Mk. II–5..	88001	56.54±.15....	.....do........	15.977+.000−.007	1.5±.05
	A. P., Mk. II–6..	72101	57. 7±.15....	.....do........	15.977+.000−.007	1.5±.05
	A. P., Mk. II–7..	72719	56.54±.15....	.....do........	15.977+.000−.007	15.94+.00−.04
	A. P., Mk. III–1.	73792	56.79±.15....	.....do........	15.977+.000−.007	15.94±.02
	A. P., Mk. III–2.	73793	56.54±.15....	.....do.......	15.977+.000−.007	15.94+.00−.04
	A. P., Mk. III–3.	73794	57.17±.15....	.....do.......	15.977+.000−.007	15.94±.02
	A. P., Mk. III–4.	88002	56.54±.15....	.....do.......	15.977+.000−.007	15.94±.02
	Target, Mk. I..	55337	56.54±.15....	.....do........	15.985+.000−.005	15.94±.02
	Target, Mk. I–1.	63427	56.54±.15....	.....do.......	15.977+.000.−007	15.94±.02
	Target, Mk. IV–1.	74549	56.54±.15....	.....do.......	15.977+.000−.007	15.94±.02
14-inch.	A. P., Mk. III...	36246	49.38+.12 −.03	98.49, 7 cal...	13.985+.000−.005	13.94±.02
	A. P., Mk. V–1..	38731	49.35±.15....	98.54, 7 cal...	13.985+.000−.005	13.94±.02
	A. P., Mk. V–2..	39738	49.35±.15....	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. V–2A.	39177	49.35±.15....	.....do.......	13.985+.000−.005	13.94±.02

[1] Front and rear.

CHARACTERISTICS OF PROJECTILES.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
2.75±.05	....	3,330 ±9.5	....	18.38+.005−.000	6.0±.01	18–1	18-inch.48.
2.75±.05	....	3,330 ±9.5	....	18.38+.005−.000	6.0±.01	18–1	Do.
2.75±.05	....	2,900 ±8.25	....	18.38+.005−.000	6.0±.01	18–1	Do.
1.5±.05	50	2,102.8 ±6	111.15	16.32+.005−.000	5.33±.01	16–2	16-inch.
1.5±.05	50	2,100±6	116	16.32+.004−.000	5.33±.01	16–2	Do.
1.5±.05	50	2,100±6	*140.58	16.32+.005−.000	5.33±.01	16–2	Do.
1.5±.05	50	2,100±6	131.27	16.32+.005−.000	5.33±.03	16–2	Do.
1.5±.05	50	2,100±6	130.77	16.32+.005−.000	5.33±.01	16–2	Do.
1.5±.05	50	2,100±6	*153	16.32+.005−.000	5.33±.01	16–2	Do.
1.5±.05	50	2,100±6	116	16.32+.005−.000	5.33±.01	16–2	Do.
1.5±.05	50	2,100±6	*141.6	16.32+.005−.000	5.33±.01	16–1	Do.
1.5±.05	50	2,100±6	116	16.32+.005−.000	5.33±.01	16–1	Do.
1.5±.05	50	2,100±6	*153	16.32+.005−.000	5.33±.01	16–1	Do.
1.5±.05	50	2,100±6	130.77	16.32+.005−.000	5.33±.01	16–1	Do.
1.5±.05	....	2,100±6	....	16.32+.005−.000	5.33±.01	16–2	Do.
1.5±.05	50	2,100±6	....	16.32+.005−.000	5.33±.01	16–2	Do.
1.5±.05	50	2,100±6	....	16.32+.005−.000	5.33±.01	16–1	Do.
1.0±.05	30.5	1,400±4	....	14.17+.005−.000	4.66±.01	14–1	All 14-inch with .075 rifling.
1.0±.05	30.5	1,400±4	*110	14.18+.005−.000	4.66±.01	14–5	Do.
1.0±.05	30.5	1,400±4	*110	14.17+.005−.000	4.66±.01	14–1	Do.
1.0±.05	30.5	1,400±4	*110	14.17+.005−.000	4.66±.01	14–1	Do.

* Includes weight of windshield.

Characteristics of projectiles—Continued.

1 Size.	2 Type mark.	3 Drawing No.	4 Length.	5 Ogive.	6 Bourrelet.	7 Diameter base.
14-inch.	A. P., Mk. V–2B.	41339	49.35±.15....	98.54, 7 cal...	13.985+.000−.005	13.94±.02
	A. P., Mk. V–2C.	41340	49.35±.15....	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. VI–2..	38477	49.489+.10 −.15	98.49, 7 cal...	13.985+.000−.005	13.94±.02
	A. P., Mk. VI–3..	45054	49.489+.10 −.15	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. VII–1.	41522	49.35+.25 −.15	98.54, 7 cal...	13.985+.000−.005	13.94±.02
	A. P., Mk. VII–2.	44727	49.60+.00 −.30	98.49, 7 cal...	13.985+.000−.005	13.94±.02
	A. P., Mk. VII–3.	45201	49.489+.10 −.15	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. VII–4.	45900	49.35±.15.....	98.54, 7 cal....	13.985+.000−.005	13.94±.02
	A. P. Mk. VII–5.	50948	49.35+.25.... −.15	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. VII–6.	57010	49.35+.25 −.15	.....do........	13.977+.000−.007	13.94±.02
	A. P., Mk. VIII–1.	46948	49.399±.15....	98.49, 7 cal....	13.985+.000−.005	13.94±.02
	A. P., Mk. VIII–2.	47225	49.25±.15.....	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. VIII–3.	47265	49.39±.15.....	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. VIII–3.	54493	49.39±.15.....	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. VIII–4.	47375	49.39±.15.....	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. VIII–5.	52982	49.023±.15....	.....do........	13.985+.000−.005	13.94±.02
	A. P., Mk. VIII–6.	54826	49.39+.15.....	.....do........	13.977+.000−.007	13.94±.02
	A. P., Mk. VIII–7.	54891	49.39±.15.....	.....do........	13.985+.000−.007	13.94±.02
	A. P., Mk. VIII–8.	57018	49.44±.15.....	.....do........	13.977+.000−.007	13.94±.02
	A. P., Mk. VIII–9.	57334	49.023±.15....	.....do........	13.977+.000−.007	13.94+.02 −.04
	A. P., Mk. VIII–10.	59082	49.47+.13 −.27	98.54, 7 cal....	13.977+.000−.007	13.94±.02

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
1.0±.05	31.5	1,400±4	*111.76	14.17+.005–.000	4.66±.01	14–1	All 14-inch with .075 rifling.
1.0±.05	31.5	1,400±4	*114.18	14.17+.005–.000	4.66±.01	14–1	Do.
1.0±.05	30.5	1,400±4	80.46	14.17+.005–.000	4.66±.01	14–1	Do.
1.0±.05	30.5	1,400±4	80.46	14.17+.005–.000	4.66±.01	14–1	Do.
1.0±.05	31.5	1,400±4	*114.18	14.17±.005	4.66±.01	14–2	Do.
1.0±.05	31.5	1,400±4	....	14.17+.005–.000	4.66±.01	14–2B	Do.
1.0±.05	31.5	1,400±4	90.38	14.17+.005–.000	4.66±.01	14–2B	Do.
1.0±.05	31.5	1,400±4	75.66	14.17±.005–.000	4.66±.01	14-2B	Do.
1.0±.05	31.5	1,400±4	*111.62	14.17±.005	4.66±.01	14-2A	Do.
1.0±.05	31.5	1,400±4	*111.62	14.17+.005–.000	4.66±.01	14-2	Do.
1.0±.05	30.13	1,400±4	91.8	14.17+.005–.000	4.66±.01	14-2	Do.
1.0±.05	29.5	1,400±4	....	14.17+.005–.000	4.66±.01	14-2	Do.
1.0±.05	29.5	1,400±4	75.66	14.17+.005–.000	4.66±.01	14-2	Do.
1.0±.05	29.5	1,400±4	75.66	14.17+.005–.000	4.66±.03	14-2	Do.
1.0±.05	29.5	1,400±4	....	14.17+.005–.000	4.66+.01	14-2	Do.
1.0±.05	30.13	1,400±4	90.61	14.17+.005–.000	4.66±.01	14-2	Do.
1.0±.05	29.5	1,400±4	*105	14.17+.005–.000	4.66±.01	14-2	Do.
1.0±.05	29.5	1,400±4	84.07	14.17+.005–.000	4.66±.03	14-2	Do.
1.0±.05	29.5	1,400±4	84.07	14.17+.005–.000	4.66±.03	14-2	Do.
1.0±.05	30.13	1,400±4	92.3	14.17+.005–.000	4.66±.01	14-2	Do.
1.0±.05	31.5	1,400±4	*111.62	14.17+.005–.000	4.66±.01	14-4	Do.

*Includes weight of windshield.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
14-inch.	A. P., Mk. VIII-11.	59300	49.44±.15.....	98.49, 7 cal....	13.977+.000−.007	13.94±.02
	A. P., Mk. VIII-12.	71741	49.47+.13 −.27	98.54, 7 cal....	13.977+.000−.007	13.94±.02
	A. P., Mk. IX...	54753	49.35+.25 −.15	.....do	13.985+.000−.005	13.94±.02
	Target, Mk. I-2.	40239	49.39±.15.....	98.49, 7 cal....	13.985+.000−.005	13.94±.02
	Target, Mk. I-3.	41799	49.39±.15.....	.....do	13.985+.000−.005	13.94±.02
	Target, Mk. I-4.	54743	49.39±.15.....	.....do	13.985+.000−.005	13.94±.02
	Target, Mk. I-5.	57531	49.25±.15.....	.....do	13.985+.000−.005	13.94±.02
	Target, Mk. I-6.	64699	49.39±.15.....	.....do	13.977+.000−.007	13.94±.02
	Target, Mk. IV..	37854	49.39±.15.....	.....do	13.985+.000−.005	13.94±.02
	Target, Mk. IV-1.	45879	49.39±.15.....	.....do	13.985+.000−.005	13.94±.02
	Target, Mk. IV-2.	48222	49.39±.15.....	.....do	13.985+.000−.005	13.94±.02
	Target, Mk. IV-3.	57250	49.39±.15.....	.....do	13.985+.000−.005	13.94±.02
	Target, Mk. IV-4.	62675	49.39±.15.....	.....do	13.977+.000−.007	13.94±.02
	Class B, Mk. IX-1.	54487	56.0±.15......	99.4, 7 cal.....	13.985+.000−.005	13.94±.02
	Class B, Mk. IX-2.	54671	56.0±.15......	.....do	13.985+.000−.005	13.94±.02
	Class B, Mk. IX-3.	55050	56.0±.15......	.....do	13.985+.000−.005	13.94±.02
	Class B, Mk. XI-1.	66162	62.05±.15.....	127.26, 9 cal...	13.977+.000−.007	13.93±.01
	Class B, Mk. XI-2.	71703	62.05±.15.....	.....do	13.977+.000−.007	13.93±.01
13-inch.	A. P., Mk. III...	31180	43.58±.05.....	39.39, 3 cal....	12.96±.01	12.88±.02

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
1.0±.05	29.5	1,400±4	84.07	14.17+.005−.000	4.66±.03	14-2	All 14-inch with .075 rifling.
1.0±.05	31.5	1,400±4	*111.62	14.17+.005−.000	4.66±.01	14-4	Do.
1.0±.05	31.5	1,400±4	*111.62	14.17±.005	4.66±.01	14-2	Do.
1.5±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14-1	Do.
1.5±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14-2B	Do.
1.5±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14-4A	Do.
1.0±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14.2	Do.
1.5±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14-2	Do.
1.5±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14-1	Do.
1.5±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14-2B	Do.
1.5±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14-2	Do.
1.5±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14-2	Do.
1.5±.05	0	1,400±4	....	14.17+.005−.000	4.66±.01	14-2	Do.
1.0±.05	88.4	1,400±4	....	14.17+.005−.000	4.66±.01	14-2	Do.
1.0±.05	88.4	1,400±4	....	14.17+.005−.000	4.66±.01	14-2	Do.
1.0±.05	88.4	1,400±4	....	14.17+.005−.000	4.66±.01	14-2	Do.
2.25±.02	135	1,177.4 ±3.5	....	14.17+.005−.000	4.66±.01	14-7	Do.
2.25±.02	135	1,177.4 ±3.5	....	14.17+.005−.000	4.65±.02	14-6	Do.
1.5±.05	22.11	1,130±3	71	13.163+.005−.000	1.74±.01	13-5	All 13-inch.

* Includes weight of wind shield.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
13-inch.	A. P., Mk. V	32603	42.22±.15	36.107, 3 cal.	12.98±.01	12.94±.02
	A. P., Mk. IX-1.	58838	46.05±.15	91.445, 7 cal.	12.977+.000−.007	12.94+.00−.04
	A. P., Mk. IX-2.	64145	46.477±.15	do	12.977+.000−.007	12.94+.00−.04
	Target, Mk. VI.	23364	45.36±.15	37,375, 3 cal.	12.98±.01	12.88±.02
	Target, Mk. VIII-1.	40022	45.80±.15	91.46, 7 cal.	12.985+.000−.005	12.94±.02
	Target, Mk. VIII-2.	57398	45.80±.15	do	12.985+.000−.005	12.94±.02
	Target, Mk. VIII-3.	62707	45.80±.15	do.	12.977+.000−.007	12.94±.02
12-inch.	A. P., Mk. III	31149	39.78±.05	36.36, 3 cal.	11.96±.01	11.88±.02
	A. P., Mk. III-1.	19254	41.37	30.15, 2.5 cal.	11.96	11.88
	A. P., Mk. V	29174	38.76±.15	30.30, 2.5 cal.	11.98±.01	11.88±.02
	A. P., Mk. VII	30650	42.65+.10 −.20	84.42, 7 cal.	11.99±.005	11.94±.02
	A. P., Mk. VIII.	32513	41.93−.20	do.	11.99±.005	11.94±.02
	A.P.,Mk.VIII-1.	33453	41.93±.15	do.	11.99±.005	11.94±.02
	A.P.,Mk.VIII-2.	35051	41.93±.20	do.	11.99±.005	11.94±.02
	A.P.,Mk.VIII-3.	35556	41.93±.15	do.	11.99±.005	11.94±.02
	A.P.,Mk.VIII-4.	36039	41.93±.15	84.62, 7 cal.	11.99±.005	11.94±.02
	A.P.,Mk.VIII-5.	36247	41.93±.15	84.55, 7 cal.	11.99±.005	11.94±.02
	A.P.,Mk.VIII-6.	39491	42.10±.15	do.	11.985+.000−.005	11.94±.02
	A. P., Mk. XII	33350	42.25±.15	84.42, 7 cal.	11.99±.005	11.94±.02
	A. P., Mk. XIII.	34844	42.25±.15	do.	11.99±.005	11.94±.02
	A. P., Mk. XIV	36436	42.25±.15	do.	11.99±.005	11.94±.02

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
1.5±.05	36.12	1,130.04 ±3	67.6	13.15+.005−.000	2.44±.02	13-3	All 13-inch. Do.
1.0±.05	27.75	1,130±3	70.48	13.12+.005−.000	4.33±.01	13-1B	Do.
1.0±.05	27.75	1,130±3	67.98	13.12+.005−.000	4.33±.01	13-1B	Do.
1.5±.05	0	1,130±3	....	13.15+.005−.000	2.44±.02	13-4	Do.
1.5±.05	0	1130±3.5	....	13.12+.005−.000	4.33±.01	13-2	Do.
1.5±.05	0	1130±3.5	....	13.12+.005−.000	4.33±.01	13-1A	Do.
1.5±.05	0	1130±3.5	....	13.12+.005−.000	4.33±.01	13-1	Do.
1.5±.05	18.18	870±2.5	54	12.163+.005 −.000	1.74±.01	12.11	B.
1.5	....	....	20.4	12.16	1.74±.01	12.12	B.
1.5±.05	11.78	870±2.5	54.5	12.14+.005−.000	3.0±.01	12-9	B.
1.0±.10	26.50	870±2.5	* 73.5	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.10	24.80	870±2.5	* 64.8	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.10	24.80	870±3	* 62.64	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.10	24.80	870±3	40.25	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.10	24.80	870±3	* 64.8	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.10	24.80	870±3	* 72	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.10	24.80	870±3	* 69	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.05	24.80	870±3	* 69	12.17+.005−.000	4.0±.01	12-4	B.
1.0±.10	24.80	870±3	53.18	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.10	24.80	870±3	....	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.05	25	870±3	53.15	12.12+.005−.000	4.0±.01	12-7	A.

* Includes weight of wind shield.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
12-inch.	A. P., Mk. XIV-2.	38742	$42.25^{+.10}_{-.20}$	84.42, 7 cal...	11.985+.000−.005	11.94±.02
	A. P., Mk. XIV-3.	38932	42.17±.15.....	.....do........	11.985+.000−.005	11.94±.02
	A. P., Mk. XIV-4.	38973	$42.20^{+.15}_{-.30}$	.....do........	11.985+.000−.005	11.94±.02
	A. P., Mk. XIV-5A.	39223	42.0±.15......	84.55, 7 cal....	11.985+.000−.005	11.94±.02
	A. P., Mk. X –5B.	39224	42.0±.15......	.....do........	11.985+.000−.005	11.94±.02
	A. P., Mk. XIV-5C.	41337	42.0±.15......	.....do........	11.985+.000−.005	11.94±.02
	A. P., Mk. XIV-5D.	41338	42.0±.15......	.....do........	11.985+.000−.005	11.94±.02
	A. P., XIV-6.....	41381	$42.25^{+.10}_{-.20}$	84.42, 7 cal....	11.985+.000−.005	11.94±.02
	A. P., Mk. XIV-7.	41372	42.17±.15.....	.....do........	11.985+.000−.005	11.94±.02
	A. P., Mk. XIV-8.	44886	42.17±.15.....	.....do........	11.985+.000−.005	11.94±.02
	A. P., Mk. XV-1.	41523	42.10±.15.....	84.55, 7 cal....	11.985+.000−.005	11.94±.02
	A. P., Mk. XV-2.	44738	42.10±.15.....	84.42, 7 cal....	11.985+.000−.005	11.94±.02
	A. P., Mk. XV-3.	44729	$42.15^{+.10}_{-.30}$	.....do........	11.985+.000−.005	11.94±.02
	A. P., Mk. XV-4.	45016	42.10±.15.....	.....do........	11.985+.000−.005	11.94±.02
	A. P., Mk. XV-5.	46939	42.15±.15.....	.....do........	11.977+.000−.007	11.94±.02
	A. P., Mk. XV-6.	59359	42.15±.15.....	.....do........	11.977+.000−.007	11.94±.02
	Cl. B...........	50387	42.0..........	47.20, 4 cal....	11.985	11.94
	Target, Mk. X-1.	40195	42.10±.15.....	84.42, 7 cal....	11.985+.000−.005	11.94±.02
	Target, Mk. X-2.	41524	42.10±.15.....	.....do........	11.985+.000−.005	11.94±.02

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	**Weight of explosive.**	**Weight complete.**	**Weight of cap.**	**Diameter.**	**Band width.**	**No.**	**Gun mark.**
1.0±.05	20.5	870±3	53.15	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	20.5	870±3	48.97	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	20.5	870±3	....	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	20.5	870±3	* 69	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	20.5	870±3	* 69	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	22	870±3	* 70.16	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	22	870±3	* 70.86	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	25.49	870±3	53.15	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	23.59	870±3	48.97	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	23.59	870±3	48.97	12.17+.005−.000	4.0±.01	12–4	B.
1.0±.05	22	870±3	* 78	12.17+.005−.000	4.0±.01	12–2A	B.
1.0±.05	22.50	870±3	....	12.17+.005−.000	4.0±.01	12–2A	B.
1.0±.05	21.50	870±3	....	12.17+.005−.000	4.0±.01	12–2A	B.
1.0±.05	21	870±3	60.16	12.17+.005−.000	4.0±.01	12–2A	B.
1.0±.05	22.5	870±3	48.97	12.17+.005−.000	4.0±.02	12–2	B.
1.0±.05	22.5	870±3	54.12	12.17+.005−.000	4.0±.02	12–2	B.
1.50	74.81	740	....	12.17	4.0	12–2	B.
1.5±.05	0	870±3	....	12.17+.005−.000	4.0±.01	12–4	B.
1.5±.05	0	870±3	....	12.17+.005−.000	4.0±.01	12–2A	B.

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* Includes weight of wind shield.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
12-inch.	Target, Mk. X-3.	41800	42.10±.15.....	84.42, 7 cal...	11.985+.000−.005	11.94±.02
	Target, Mk. X-4.	45842	42.10±.15.....	.....do........	11.985+.000−.005	11.94±.02
	Target, Mk. X-5.	48221	42.10±.15.....	.....do........	11.985+.000−.005	11.94±.02
	Target, Mk. X-6.	48437	42.10±.15.....	.....do........	11.985+.000−.005	11.94±.02
	Target Mk. X-7.	50388	42.10±.15.....	.....do........	11.985+.000−.005	11.94±.02
	Target Mk. X-8.	54744	42.10±.15.....	.....do........	11.985+.000−.005	11.94±.02
	Target Mk. XI.	32887	41.56±.35.....	.....do........	11.99±.005	11.94±.02
	Target Mk. XI-1	38704	41.56±.35.....	.....do........	11.985+.000−.005	11.94±.02
	Target Mk. XI-2	39499	41.54±.35.....	.....do........	11.985+.000−.005	11.94±.02
	Target Mk. XI-3	54746	42.10±.15.....	.....do........	11.985+.000−.005	11.94±.02
	.....do..........	54746	42.10±.15.....	.....do........	11.985+.000−.005	11.94±.02
	Target Mk. XI-4	60286	42.10±.15.....	.....do........	11.977+.000−.007	11.94±.02
	.....do..........	60286	42.10±.15.....	.....do........	11.977+.000−.007	11.94±.02
10-inch.	A. P., Mk. III...	31148	33.31±.05.....	30.30, 3 cal...	9.96±.01	9.88±.02
	A. P., Mk. V.....	32512	35.16±.15.....	70.35, 7 cal...	9.99±.005	9.94±.02
	A. P., Mk. VI....	33215	35.45±.15.....	.....do........	9.99±.005	9.95+.01−.03
	A. P., Mk. VI-1..	35795	35.207±.15...	.....do........	9.99±.005	9.94±.02
	A. P., Mk. VI-2..	36781	35.33±.15.....	.....do........	9.99±.005	9.94±.02
	A. P., Mk. VI-3..	47273	35.20±.15.....	.....do........	9.985+.000−.005	9.94±.02
	Target, Mk. VII-1.	35426	34.67±.3......	70.35, 7 cal....	9.99±.005	9.94±.02
	Target, Mk. VII-2.	40021	35.20±.15.....	.....do........	9.985+.000−.005	9.94±.02
	Target, Mk. VII-3.	62778	35.20±.15.....	.....do........	9.977+.000−.007	9.94±.02

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
1.5±.05	0	870±3	....	12.17+.005−.000	4.0±.01	12-2A	B.
1.5±.05	0	870±3	....	12.17+.005−.000	4.0±.01	12-2A	B.
1.5±.05	0	870±3	....	12.17+.005−.000	4.0±.01	12-2	B.
1.5±.05	0	870±3	....	12.12+.005−.000	4.0±.01	12-6	A.
1.5±.05	0	870±3	....	12.17+.005−.000	4.0±.01	12-2	B.
1.5±.05	0	870±3	....	12.12+.005−.000	4.0±.01	12-6A	A.
1.0±.05	0	870±3	....	12.12+.005−.000	4.0±.01	12-1	A.
1.0±.05	0	870±3	....	12.18+.005−.000	4.0±.01	12-8	B.
1.0±.05	0	870±3	....	12.18+.005−.000	4.0±.01	12-8	B.
1.5±.05	0	870±3	....	12.17+.005−.000	4.0±.01	12-2B	B.
1.5±.05	0	870±3	....	12.12+.005−.000	4.0±.01	12-6	A.
1.5±.05	0	870±3	....	12.17+.005−.000	4.0±.01	12-2	B.
1.5±.05	0	870±3	....	12.12+.005−.000	4.0±.01	12-6	A.
1.5±.05	9.75	5.10±2	32	10.153+.005−.000	1.65±.01	10-4	All 10-inch.
1.0±.10	13.22	5.10±2	* 37.5	10.12+.005.−000	3.33±.01	10-1	Do.
1.0±.05	13.22	5.10±2	....	10.12+.005−.000	3.33±.01	10-1	Do.
1.0±.05	13.22	5.10±2	31.69	10.12+.005−.000	3.33±.01	10-1	Do.
1.0±.10	13.22	5.10±2	* 35.25	10.12+.005−.000	3.33±.01	10-1	Do.
1.0±.05	13.25	5.10±2	....	10.12+.005−.000	3.33±.01	10-1	Do.
1.0±.05	0	5.10±2	....	10.12+.005−.000	3.33±.01	10-1	Do.
1.50±.05	0	5.10±2	....	10.12+.005−.000	3.33±.01	10-2	Do.
1.50±.05	0	51.0±2	....	10.12+.005−.000	3.33±.01	10-3	Do.

* Includes weight of wind shield.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
8-inch	A. P., Mk. III	19253	27.0	20.15, 2.5 cal.	7.96	7.93
	A. P., Mk. III-1	20201	26.76±.05	do.	7.96±.01	7.93±.02
	A. P., Mk. IV	21510	27.0±.05	24.18, 3 cal.	7.96±.01	7.90±.02
	A. P., Mk. V-1	24767	27.0±.15	20.15, 2.5 cal.	7.98±.01	7.90±.02
	A. P., Mk. VI	30297	28.20±.20		7.99±.005	7.94±.02
	A. P., Mk. VII-1	33014	28.20±.15	56.28, 7 cal.	7.99±.005	7.94±.02
	A. P., Mk. VII-2	32511	27.89±.15	do.	7.99±.005	7.94±.02
	A. P., Mk. VII-3	35841	27.964±.15	do.	7.99±.005	7.94±.02
	A. P., Mk. VII-4	36388	28.03±.15	56.315, 7 cal.	7.99±.005	7.94±.02
	A. P., Mk. VII-5	36389	28.03±.15	do.	7.99±.005	7.94±.02
	A. P., Mk. VII-5A.	39490	28.03±.15	do.	7.985+.000−.005	7.94±.02
	A. P., Mk. VII-6	44777	28.18±.15	56.28, 7 cal.	7.985+.000−.005	7.94±.02
	A. P., Mk. VII-7	38936	28.03±.15	56.315, 7 cal.	7.985+.000−.005	7.94±.02
	A. P., Mk. VII-7A.	39217	28.06±.15	do.	7.985+.000−.005	7.94±.02
	A. P., Mk. VII-7B.	40646	28.06	56.345, 7 cal.	7.985+.000−.005	7.94±.02
	A. P., Mk. VII-7C.	40647	28.06±	do.	7.985+.000−.005	7.94±.02
	A. P., Mk. VII-8	38974	28.10+.10 −.15	56.28, 7 cal.	7.985+.000−.005	7.94±.02
	A. P., Mk. VII-9	44914	28.18±.15	do.	7.985+.000−.005	7.94±.02
	A. P., Mk. X-1	41537	28.06±.15	56.345, 7 cal.	7.985+.000−.005	7.94±.02
	A. P., Mk. XI-1	62688	28.10±.15	56.28, 7 cal.	7.985+.000−.005	7.94±.02
	Target, Mk. VIII.	32483	27.50±.25	do.	7.99±.005	7.94±.02
	Target, Mk. VIII-1.	35403	27.50±.25	do.	7.99±.005	7.94±.02

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
1.5	....	....	7.2	8.14	1.35	8–2	All 8-inch.
1.5±.05	5.96	260±1	14.14	8.14±008	1.33±.01	8–2	Do.
1.5±.05	5.80	260±1	16	8.14±.008	1.35±.01	8–2	Do.
1.5±.05	....	260±1	12.38	8.14+.005−.000	1.88±.01	8–4	Do.
1.0±.10	5.39	260±1	* 22.67	8.12+.005−.000	2.66±.01	8–1	Do.
1.0±.10	5.49	260±1	....	8.12+.005−.000	2.66±.01	8–1	Do.
1.0±.10	5.48	260±1	* 19.2	8.12+.005−.000	2.66±.01	8–1	Do.
1.0±.10	5.49	260±1	15.84	8.12+.005−.000	2.66±.01	8–1	Do.
1.0±.10	5.49	260±1	16.99	8.12+.005−.000	2.66±.01	8–1	Do.
1.0±.10	5.49	260±1	* 18	8.12+.005−.000	2.66±.01	8–1	Do.
1.0±.05	4.40	260±1	* 18	8.12+.005−.000	2.66±.01	8–1	Do.
1.0±.05	5.50	260±1	* 15.64	8.12+.005−.000	2.66±.01	8–3	Do.
1.0±.05	5.49	260±1	* 18	8.12+.005−.000	2.66±.01	8–3	Do.
1.0±.05	4.50	260±1	* 18	8.12+.005−.000	2.66±.01	8–3	Do.
1.0±.05	5.50	260±1	* 19	8.12+.005−.000	2.66±.01	8–3	Do.
1.0±.05	5.50	260±1	* 19	8.12+.005−.000	2.66±.01	8–3	Do.
1.0±.10	5.46	260±1	....	8.12+.005−.000	2.66±.01	8–5	Do.
1.0±.10	5.50	260±1	15.64	8.12+.005−.000	2.66±.01	8–3	Do.
1.0±.10	5.50	260±1	* 19	8.12+.005−.000	2.66±.01	8–5	Do.
1.0±.10	5.50	260±1	11.37	8.12+.005−.000	2.66±.02	8–5	Do.
1.0±.15	0	260±1	....	8.12+.005−.000	2.66±.01	8–1	Do.
1.0±.05	0	260±1	....	8.12+.005−.000	2.66±.01	8–1	Do.

Characteristics of projectiles—Continued.

1 Size.	2 Type mark.	3 Drawing No.	4 Length.	5 Ogive.	6 Bourrelet.	7 Diameter base.
8-inch..	Target, Mk. VIII-2.	38924	27.50±.25.....	56.28, 7 cal...	7.985+.000−.005	7.94±.02
	Target, Mk. IX-1.	39754	28.0±.15.....	.....do........	7.985+.000−.005	7.94±.02
	Target, Mk. IX-2.	45851	28.0±.15.....	.....do........	7.985+.000−.005	7.94±.02
	Target, Mk. IX-3.	48528	28.0±.15.....	.....do........	7.985+.000−.005	7.94±.02
	Target, Mk. X..	54866	28.0±.15.....	.....do........	7.985+.000−.005	7.94±.02
	Target, Mk. X-1.	62779	28.0±.15.....	.....do........	7.977+.000−.007	7.94±.02
	Flat nose, Mk. XII-4.	62634	43.25±.15.....	Flat nose.....	7.97+.000−.007	7.92±.01
7-inch..	A. P., Mk. II-1..	21451	22.89±.15.....	21.18, 3 cal....	6.98±.01	6.90±.01
	A. P., Mk. VI....	32510	23.65±.15.....	49.245, 7 cal..	6.99±.005	6.94±.02
	A. P., Mk. VI-1.	33452	23.64±.15.....	.....do........	6.99±.005	6.94±.02
	A. P., Mk. VII...	24766	22.48±.15.....	21.18, 3 cal....	6.98±.01	6.90±.01
	A. P., Mk. VIII..	28522	21.57±.15.....	17.65, 2.5 cal..	6.98±.01	6.96±.02
	A. P., Mk. IX....	31146	22.48±.15.....	21.18, 3 cal....	6.98±.01	6.90±.01
	A. P., Mk. X-1..	36390	23.73±.15.....	49.28, 7 cal....	6.99±.005	6.94±.02
	A. P., Mk. X-2..	36391	23.73±.15.....	.....do........	6.99±.005	6.94±.02
	A. P., Mk. XII-1	41385	23.68+.11 −.19	49.27, 7 cal....	6.985+.000−.005	6.94±.02
	A. P., Mk. XII-2	44730	23.75+.04 −.26	49.245, 7 cal..	6.985+.000−.005	6.94±.02
	A. P., Mk. XII-3	54890	23.73±.15.....	.....do........	6.985+.000−.005	6.94±.02
	A. P., Mk. IV-1..	38488	23.64±.15.....	.....do........	6.96±.01	6.94±.01
	A. P., Mk. VIII-1	38490	23.57±.15.....	.....do........	6.98±.01	6.96±.02
	A. P., Mk. IX-1.	38485	23.64±.15.....	.....do........	6.96±.01	6.94±.01

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	**Weight of explosive.**	**Weight complete.**	**Weight of cap.**	**Diameter.**	**Band width.**	**No.**	**Gun mark.**
1.0±.05	0	260±1	....	8.12+.005−.000	2.66±.01	8–1	All 8-inch.
1.5±.05	0	260±1	....	8.12+.005−.000	2.66±.01	8–3	Do.
1.5±.05	0	260±1	....	8.12+.005−.000	2.66±.01	8–5	Do.
1.5±.05	0	260±1	....	8.12+.005−.000	2.66±.01	8–5	Do.
1.5±.05	0	260±1	....	8.12+.005−.000	2.66±.01	8–5	Do.
1.5±.05	0	260±1	....	8.12+.005−.000	2.66±.01	8–5	Do.
1.52±.05	75	285.31±1	....	8.12+.005−.000	1.5±.01	8–6	Do.
1.5±.05	2.58	165±.75	12.5	7.13+.005−.000	1.78±.01	7–6	All 7-inch.
1.0±.10	4.31	165±.75	*12.8	7.12+.005−.000	2.33±.01	7–1	Do.
1.0±1.0	4.31	165±.75	12.8	7.12+.005−.000	2.33±.01	7–1	Do.
1.5±.05	2.75	165±.75	8.77	7.13+.005−.000	1.78±.01	7–6	Do.
1.5±.05	2.19	165±.75	10.8	7.13+.005−.000	1.78±.01	7–5	Do.
1.5±.05	2.75	165±.75	8.77	7.13+.005−.000	1.78±.01	7–6	Do.
1.0±.10	4.31	165±.75	*11.5	7.12+.005−.000	2.33±.01	7–1	Do.
1.5±.10	4.31	165±.75	*12	7.12+.005−.000	2.33±.01	7–1	Do.
1.0±.05	4.0	165±.75	*13	7.12+.005−.000	2.33±.01	7–3A	Do.
1.0±.05	3.50	165±.75	....	7.12+.005−.000	2.33±.01	7–3A	Do.
1.0±.05	3.50	165±.75	....	7.12+.005−.000	2.33±.01	7–3	Do.
1.0±.05	3.23	165±.75	....	7.12+.005−.000	2.33±.01	7–1	Do.
1.5±.05	2.19	165±.75	....	7.13+.005−.000	1.78±.01	7–5	Do.
1.0±.05	2.75	165±.75	....	7.12+.005−.000	2.33±.01	7–1	Do.

* Includes weight of wind shield.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	**Type mark.**	**Drawing No.**	**Length.**	**Ogive.**	**Bourrelet.**	**Diameter base.**
7-inch..	Target, Mk. XI.	35213	23.48±.20.....	49.245, 7 cal..	6.99±.005	6.94±.02
	Target, Mk. XI-1.	37924	23.48±.20.....	.....do........	6.985+.000−.005	6.94±.02
	Target, Mk. XI-2.	39739	23.64±.15.....	.....do........	6.985+.000−.005	6.94±.02
	Target, Mk. XI-3.	45850	23.64±.15.....	.....do........	6.985+.000−.005	6.94±.02
	Target, Mk. XI-4.	48527	23.64±.15.....	.....do........	6.985+.000−.005	6.94±.02
	Target, Mk. XI-5.	62708	23.64±.15.....	.....do........	6.985+.000−.008	6.94±.02
	Cl. B, Mk. XIII-1.	59444	28.84±.15.....	28.28, 4 cal....	6.985+.000−.008	6.94±.02
	Cl. B, Mk. XIII-2.	64338	28.84±.15.....	.....do........	6.985+.000−.008	6.94±.02
	Cl. B, Mk. XIV-1.	64156	28.84±.15.....	.....do........	6.985+.000−.008	6.94±.02
	Cl. B, Mk. XIV-2.	64337	28.84±.15.....	.....do........	6.985+.000−.008	6.94±.02
6-inch...	A. P., ribbed cavity.	22955	19.70±.05.....	16.04, 2.7 cal..	5.98±.01	5.93
	A. P., Mk. I-1..	20532	18.467±.05...	12.08, 2 cal....	5.96±.01	5.93±.02
	A. P., Mk. I-2..	18409	19.76	15.0, 2.5 cal...	5.96	5.94
	A. P., Mk. I-3..	21511	19.41±.15	18.18, 3 cal....	5.96±.01	5.90±.02
	A. P., Mk. V., ribbed cavity.	27812	18.97±.05	16.04, 2.7 cal..	5.98±.01	5.93±.01
	A. P., Mk. VI...	27939	19.41±.15	18.18, 3 cal....	5.98±.01	5.92±.01
	A. P., Mk. VII..	29409	18.84±.15	.....do........	5.98±.01	5.94±.02
	A. P., Mk. VIII..	30651	21.0±.15......	42.21, 7 cal....	5.99±.005	5.94±.02
	A. P., Mk. IX...	32509	20.40±.15	.....do........	5.99±.005	5.94±.02
	A. P., Mk. IX-1.	33451	20.40±.15	.....do........	5.99±.005	5.94±.02

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	**Weight of explosive.**	**Weight complete.**	**Weight of cap.**	**Diameter.**	**Band width.**	**No.**	**Gun mark.**
1.0±.05	0	165±.75	....	7.12+.005−.000	2.33±.01	7–1	All 7-inch.
1.0±.05	0	165±.75	....	7.12+.005−.000	2.33±.01	7–1	Do.
1.5±.05	0	165±.75	....	7.12+.005−.000	2.33±.01	7–4	Do.
1.5±.05	0	165±.75	....	7.12+.005−.000	2.33±.01	7–3	Do.
1.5±.05	0	165±.75	....	7.12+.005−.000	2.33±.01	7–3	Do.
1.5±.05	0	165±.75	....	7.12+.005−.000	2.33±.01	7–3	Do.
1.0±.05	24	153±.75	....	7.12+.005−.000	2.33±.01	7–3	Do.
1.0±.05	24	153±.75	....	7.12+.005−.000	2.33±.01	7–2	Do.
1.0±.05	24	153±.75	....	7.12+.005−.000	2.33±.01	7–3	Do.
1.0±.05	24	153±.75	....	7.12+.005−.000	2.33±.01	7–2	Do.
2.45±.05	....	105±.5	....	6.12+.005−.000	1.15±.01	6–11	6″/40, 6″/44.
1.5±.05	....	....	....	6.12±.008	1.15±.01	6–11A	6″/40, 6″/44.
1.5	....	....	5	6.12	1.15	6–7	6″/40, 6″/44.
1.5±.05	2.0	105	6.75	6.12±.008	1.15±.01	6–4	6″/40, 6″/44.
2.45±.05	....	105±.5	....	6.12+.005−.000	1.15±.01	6–11	6″/40, 6″/44.
1.5±.05	....	....	....	6.12+.005−.000	1.558±.01	6–8A	6″/40, 6″/44.
1.5±.05	2.20	105±.5	6.7	6.12+.005−.000	1.558±.01	6–8	6″/40, 6″/44.
1.0±.10	2.50	105±.5	*7.5	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.
1.0±.10	2.50	105±.5	*8.1	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.
1.0±.10	2.50	105±.5	7.83	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.

* Includes weight of wind shield.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
6-inch	A. P., Mk. IX-2.	35052	20.40±.15	42.21, 7 cal.	5.99±.005	5.94±.02
	A. P., Mk. IX-3.	35414	20.40±.15	do	5.99±.005	5.94±.02
	A. P., Mk. IX-4.	35563	20.40±.15	do	5.99±.005	5.94±.02
	A. P., Mk. IX-5.	36038	20.44±.15	42.31, 7 cal.	5.99±.005	5.94±.02
	A. P., Mk. IX-6.	36272	20.34±.15	do	5.99±.005	5.94±.02
	A. P., Mk. XVIII-1.	41384	20.375+.15 −.25	42.275, 7 cal.	5.985+.000−.005	5.94±.02
	A. P., Mk. XVIII-2.	44728	20.50+.05 −.25±.25	42.21, 7 cal.	5.985+.000−.005	5.94±.02
	Target, Mk. XIV-1.	40017	20.40±.15	do	5.985+.000−.005	5.94±.02
	Target, Mk. XIV-2.	45849	20.40±.15	do	5.985+.000−.005	5.94±.02
	Target, Mk. XIV-3.	48526	20.40±.15	do	5.985+.000−.005	5.94±.02
	Target, Mk. XIV-4.	57529	22.85±.15	45.50, 7.6 cal.	5.985+.000−.005	5.94±.02
	Target, Mk. XIV-5.	59379	20.40±.15	42.21, 7 cal.	5.985+.000−.008	5.94±.02
	Target, Mk. XVI.	33596	19.66±.15	do	5.99±.005	5.94±.02
	Target, Mk. XVII.	37853	20.41±.15	do	5.985+.000−.005	5.94±.02
	Target, Mk. XVII-1.	62674	20.40±.15	do	5.985+.000−.005	5.94±.02
	Common, Mk. XIX-1.	47707	22.75±.15	do	5.985+.000−.005	5.94±0.2
	Common, Mk. XX-1.	50418	22.85±.15	45.50, 7.5 cal.	5.985+.000−.005	5.94±.02
	Common, Mk. XX-2.	53520	22.70±.15	do	5.985+.000−.005	5.94±.02
	Common, Mk. XX-3.	56378	23.22±.15	do	5.985+.000−.005	5.94±.02

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
1.0±.10	2.50	105±.5	4.87	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.
1.0±.10	2.50	105±.5	*8.1	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.
1.0±.10	2.50	105±.5	*8.1	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.
1.0±.10	2.50	105±.5	*8.87	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.
1.0±.10	2.50	105±.5	*9.7	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.
1.0±.5	2.50	105±.5	*9.48	6.12+.005−.000	2.0±.01	6–1	6″/50, 6″/53.
1.0±.5	2.30	105±.5	....	6.12+.005−.000	2.0±.01	6–3	6″/50, 6″/53.
1.0±.5	0	105±.5	....	6.12+.005−.000	2.0±.01	6–5	6″/50, 6″/53.
1.0±.5	0	105±.5	....	6.12+.005−.000	2.0±.01	6–1	6″/50, 6″/53.
1.0±.5	0	105±.6	....	6.12+.005−.000	2.0±.01	6–1	6″/50, 6″/53.
1.0±.5	0	105±.5	....	6.12+.005−.000	2.0±.01	6–1	6″/50, 6″/53.
1.0±.5	0	105±.5	....	6.12+.005−.000	2.0±.01	6–1	6″/50, 6″/53.
1.0±.5	0	105±.5	....	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.
1.0±.10	0	105±.5	....	6.12+.005−.000	2.0±.01	6–6	6″/50, 6″/53.
1.0±.05	0	105±.5	....	6.12+.005−.000	2.0±.01	6–1	6″/50. 6″/53.
1.0±.05	6.75	105±.5	....	6.12+.005−.000	2.0±.01	6–1	6″/50, 6″/53.
1.0±.05	6.25	....	....	6.12+.005−.000	2.0±.01	6–2	6″/50, 6″/53.
1.0±.05	....	....	....	....	....	6–1	6″/50, 6″/53.
1.0±.05	6.25	105±.5	....	6.12+.005−.000	2.0±.01	6–1	6″/50, 6″/53.

*Includes weight of wind shield.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
6-inch..	Common, Mk. XX-4.	57012	22.70±.15	45.50, 7.5 cal.	5.985+.000−.005	5.94±.02
	Flat nose, Mk. XXI.	56179	21.59±.15	Flat nose......	5.985+.000−.005	5.94±.02
	Flat nose, Mk. XXI-1.	60211	21.59±.15	.....do........	5.985+.000−.005	5.94±.02
5-inch..	A. P., Mk. VI...	26311	16.81±.15	9.96, 2 cal.....	4.99+.000−.005	4.91
	A. P., Mk. IX...	30681	16.85±.15	35.175, 7 cal..	4.98±.01	4.96±.01
	A. P., Mk. XIII.	24253	16.50±.15	15.18, 3 cal....	4.98±.01	4.94±.01
	Target, Mk. X..	35772	17.11±.15	35.175, 7 cal..	4.99+.005−.000	4.96±.015
	Target, Mk. X-1	35771	17.11±.15	.....do........	4.99+.005−.000	4.96±.015
	Target, Mk. X-2	38705	17.11±.15	.....do........	4.985+.000−.005	4.96±.015
	Target, Mk. X-3	39971	17.11±.15	.....do........	4.985+.000−.005	4.96±.015
	Target, Mk. X-4	40032	17.11±.15	.....do........	4.99+.005−.000	4.96±.015
	Target Mk. X-5.	41308	17.11±.15.....	.....do........	4.985	+.000−.005
	Target Mk. X-6.	45868	17.11±.15.....	35.175, 7 cal..	4.985	....
	Target Mk. X-7.	48525 54483	17.11±.15.....	.....do........	4.985	....
	Target Mk. X-8.	57343	17.11±.15.....	.....do........	4.985	....
	Target Mk. X-9.	70330	17.11±.15.....	.....do........	4.985	+.000−.008
	Target Mk. XVI	42834	17.11±.15.....	35.75, 7 cal...	4.985	+.000−.005
	Target Mk. XVII-1.	57342	17.20±.15.....	9.97, 2 cal.....	....	+.000−.005
	Flat nose Mk. XIX.	55042	16.19±.15.....	Flat nose......	....	+.000−.005
	Flat nose Mk. XIX-1.	63009	16.19±.15.....	.....do........	4.985	+.000−.008
	Flat nose Mk. XX.	56550	16.19±.15.....	.....do........	4.985	+.000−.005
	Flat nose Mk. XX-1.	63010	16.19±.15.....	.....do........	4.985	+.000−.008

Characteristics of projectiles—Continued.

8 Band to base.	9 Weight of explosive.	10 Weight complete.	11 Weight of cap.	12 Diameter.	13 Band width.	14 No.	15 Gun mark.
1.0±.05	6.25	105±.5	....	6.12+.005−.000	2.0±.01	6–1A	6″/50, 6″/53.
1.0±.05	14.80	105±.5	....	6.12±.003	2.0±.02	6–1	6″/50, 6″/53.
1.0±.05	14.80	105±.5	....	6.12±.003	2.0±.02	6–1	6″/50, 6″/53.
1.50±.05	....	60	6.25	5.12±.008	1.15±.01	5–9B	5″/50.
1.50±.05	1.6	60	....	5.12±.005	1.35±.01	5–4	5″/50.
1.50±.05	1	60	4.50	5.083+.005−.000	1.15±.01	5–8	5″/40.
.65±.05	0	50±.3	....	5.12+.005−.000	1.67±.01	5–3	5″/50, 5″/51
.65±.05	0	60±.3	....	5.12+.005−.000	1.67±.01	5–3	5″/50, 5″/51
.65±.05	0	50±.3	....	5.12+.005−.000	1.67±.01	5–2	5″/50, 5″/51
.65±.05	0	60±.3	....	5.12+.005−.000	1.67±.01	5–2	5″/50, 5″/51
.65±.05	0	50±.3	....	5.12+.005−.000	1.67±.01	5–3	5″/50, 5″/51
.65±.05	0	0	4.50	5.12+.005−.000	1.67±.01	5–2	5″/51
.65±.05	0	0	4.50	5.12+.005−.000	1.67±.01	5–1	5″/51
.65±.05	1.0±.05	0	50±.4	5.12+.005−.000	1.67±.04	5–1	5″/51
.65±.05	1.0±.05	0	50±.3	5.12+.005−.000	1.67±.01	5–1	5″/51
.65±.05	1.0±.05	0	50±.3	5.12+.005−.000	1.67±.01	5–1	5″/51
.65±.05	.65±.05	0	50±.3	5.12+.005−.000	1.67±.01	5–1	5″/51
4.96±.01	1.5±.035	0	60±.5	5.12+.005−.000	1.15±.01	5–9	5″/51
4.94±.01	.65±.05	....	....	5.12+.005−.000	1.67±.01	5–1	5″/51
4.94±.01	.65±.05	8.32	50±.5	5.12+.005−.000	1.67±.01	5–1	5″/51
4.973±.003	2.43±.025	....	....	5.08+.005−.000	1.15±.01	5–6	5″/40
4.973±.003	2.43±.025	8.32	50±.3	5.08+.005−.000	1.15±.01	5–6	5″/40

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
5-inch	Common ribbed cavity.	34046	15.5±.15	10.06, 2 cal.	4.99+.000−.005	....
	Common, Mk. 1-3.	54240	14.72±.15	9.92, 2 cal.	4.96±.01	4.973±.003
	Common, Mk. I-4.	58463	14.72±.15	do.	4.96±.01	4.973±.003
	Common, Mk. VII.	28048	17.35±.15	10.50, 2 cal.	4.98±.01	4.96 ±.01
	Common, Mk. XII.	20498	17.34±.15	9.92, 2 cal.	4.96±.01	4.91
	Common, Mk. XIV.	33668	17.11±.15	35.175, 7 cal.	4.99±.05	4.96 ±.015
	Common, Mk. XV-1.	35415	17.0±.15	do.	4.99±.05	4.96 ±.015
	Common, Mk. XV-2.	39190	17.0±.15	do.	4.985+.000−.005	4.96 ±.015
	Common, Mk. XV-3.	39565	17.0±.15	do.	4.985+.000−.005	4.96 ±.015
	Common, Mk. XV-4.	39566	17.0±.15	do.	4.985+.000−.005	4.96 ±.015
	Common, Mk. XV-6.	41325	17.0±.15	do.	4.985+.000−.005	4.96 ±.015
	Common, Mk. XV-7.	41349	17.0±.15	do.	4.985+.000−.005	4.96 ±.015
	Common, Mk. XV-8.	41350	17.0±.15	do.	4.985+.000−.005	4.94 ±.05
	Common, Mk. XV-9.	41387	17.0±.15	do.	4.985+.000−.005	4.94 ±.05
	Common, Mk. XV-10.	39565	17.0±.15	do.	4.985+.000−.005	4.96 ±.015
	Common, Mk. XV-11.	46931	17.0±.15	do.	4.985+.000−.005	4.94 ±.05
	Common, Mk. XV-12.	46962	17.0±.15	do.	4.985+.000−:005	4.94 ±.05

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	**Weight of explosive.**	**Weight complete.**	**Weight of cap.**	**Diameter.**	**Band width.**	**No.**	**Gun mark.**
4.96±.01	1.3	....	....	5.12±.008	6.25±.01	5-10	5″/50, 5″/51
2.43±.025	....	....	....	5.08+.005−.000	1.15±.01	5-6	5″/40
2.43±.025	....	....	....	5.08+.005−.000	1.15±.01	5-6	5″/40
2.34±.035	2.6	60±.50	....	5.12±.008	1.15±.01	5-9A	5″/50, 5″/51
1.50±.035	2.6	60	....	5.12±.008	1.15±.01	5-9	5″/50, 5″/51
.65±.05	1.73	50.40±.60	....	5.12+.005−.000	1.67±.01	5-3	5″/50, 5″/51
.65±.05	1.73	50.0±.30	....	5.12+.005−.000	1.67±.01	5-3	5″/50, 5″/51
.65±.05	1.73	50.0±.30	....	5.12+.005−.000	1.67±.01	5-2	5″/50, 5″/51
.65±.05	1.70	50.0±.50	....	5.12+.005−.000	1.67±.01	5-2	5″/50, 5″/51
.65±.05	1.73	50.0±.30	....	5.12+.005−.000	1.67±.01	5-2	5″/50, 5″/51
.65±.05	1.73	50.0±.30	....	5.12+.005−.000	1.67±.01	5-2	5″/50, 5″/51
.65±.05	1.73	50.0±.30	....	5.12+.005−.000	1.67±.01	5-2	5″/50, 5″/51
.65±.05	1.70	50.0±.30	....	5.12+.005−.000	1.67±.01	5-1	5″/50, 5″/51
.63±.05	1.70	50.0±.30	....	5.12+.005−.000	1.67±.01	5-1	5″/50, 5″/51
.65±.05	1.70	50.0±.50	....	5.12+.005−.000	1.67±.01	5-2	5″/50, 5″/51
.65±.05	1.70	50.0±.30	....	5.12+.005−.000	1.67±.01	5-1	5″/50, 5″/51
.65±.05	1.70	50.0±.30	....	5.12+.005−.000	1.67±.01	5-1	5″/50, 5″/51

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
5-inch	Common, Mk. XV-13.	48651	17.0±.15	35.175, 7 cal.	4.985+.000−.005	4.94 ±.05
	Common, Mk. XV-14.	53175	17.0±.15	do.	4.985+.000−.005	4.94 ±.05
	Common, Mk. XV-15.	54905	17.0±.15	do.	4.985+.000−.005	4.94 ±.05
	Common, Mk. XV-16.	56384	17.0±.15	do.	4.985+.000−.005	4.94 ±.05
	Smoke, Mk. XXI-1.	59431	17.57	9.9, 2 cal.	4.95±.01	4.94 ±.05
	Illuminating, Mk. XXII-1.	64925	17.57+.08 −.06		4.985+.000−.008	4.95 ±.01
	Illuminating, Mk. XXII-2.	74073	17.57+.08 −.06		4.985+.000−.008	4.95 ±.01
4-inch	Forged steel	34047	14.15±.15	7.92, 2 cal.	3.96±.01	3.96±.003
	Common, Mk. III-2.	54241	13.95±.15	7.92, 2 cal.	3.96±.01	3.96±.003
	Common, Mk. III-3.	58455	13.89±.15	do.	3.96±.01	3.96±.003
	Common, Mk. VI.	55378	15.80+.10 −.15	28.0, 7 cal.	3.985+.000−.008	3.96±.003
	Common, Mk. VI-1.	41370	15.65+.10 −.05	do.	3.985+.000−.005	3.96±.003
	Common, Mk. VI-2.	41801	16.0+.05 −.10	do.	3.985+.000−.005	3.96±.003
	Common, Mk. VI-3.	49766	16.0+.05 −.10	do.	3.985+.000−.005	3.96±.003
	Common, Mk. VI-4.	50644	15.65+.10 −.05	do.	3.985+.000−.005	3.96±.003
	Common, Mk. VI-5.	53499	15.65+.10 −.05	do.	3.985+.000−.008	3.96±.003
	Common, Mk. VI-6.	56001	15.80+.10 −.05	do.	3.985+.000−.008	3.96±.003

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
.65±.05	1.70	50.0±.30	....	5.12+.005−.000	1.67±.01	5–1	5″/50, 5″/51
.65±.05	1.70	50.0±.30	....	5.12+.005−.000	1.67±.01	5–1	5″/50, 5″/51
.65±.05	1.70	50.0±.30	....	5.12+.005−.000	1.67±.01	5–1	5″/50, 5″/51
.65±.05	1.70	50.0±.30	....	5.12+.005−.000	1.67±.01	5–1	5″/50, 5″/51
.65±.05	1.18	50±.5	....	5.12+.005−.000	1.67±.01	5–1	5″/50, 5″/51
1.03+.095 −.015	....	50±.5	....	5.12+.005−.000	1.67±.01	5–1	5″/50, 5″/51
1.03+.10 −.02	....	50±.5	....	5.12+.005−.000	1.67±.01	5–1	5″/50, 5″/51
2.90±.025	....	....	....	4.07±.008	1.02±.01	4–3	4″/40
2.90±.015	....	33±.30	....	4.07+.005−.000	1.02±.01	4–5	4″/40.
2.90±.015	....	....	....	4.07+.005−.000	1.02±.01	4–5	4″/40.
2.90±.015	1.39	33±.50	....	4.08+.003−.000	1.02±.01	4–1	4″/50, Mk. VII and VIII.
2.90±.015	1.10	33±.50	....	4.07+.005−.000	1.02±.01	4–9	Do.
2.90±.015	1.10	33±.50	....	4.07+.005−.000	1.02±.01	4–9	Do.
2.90±.015	1.10	33±.50	....	4.08+.003−.000	1.02±.01	4–2	Do.
2.90±.015	1.10	33±.50	....	4.08+.003−.000	1.02±.01	4–8	Do.
2.90±.015	....	....	....	4.08+.003−.000	1.02±.01	4–2	Do.
2.90±.015	....	....	....	4.12+.003−.000	1.02±.01	4–1	4″/50, Mk. IX, .05 rifling.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
4-inch.	Common, Mk. VI-7.	56002	15.80+.10 −.05	28.0, 7 cal.	3.985+.000−.008	3.96±.003
	Common, Mk. X.	56569	15.69±.10	do.	3.985+.000−.008	3.96±.003
	Common, Mk. X-1.	56788	15.80±.10	do.	3.985+.000−.008	3.96±.003
	Common, Mk. X-2.	59488	15.80±.10	do.	3.985+.000−.008	3.96±.003
	Common, Mk. X-3.	70746	15.69±.10	do.	3.985+.000−.008	3.96±.003
	A. P., Mk. IV.	24605	14.04±.05	7.92, 2 cal.	3.98±.01	3.96±.003
	Target, Mk. V.	45848	13.89±.15	7.98, 2 cal.	3.985+.000−.005	3.96±.01
	Target, Mk. V-2.	50390	14.08±.15	do.	3.985+.000−.005	3.96±.003
	Target, Mk. VII-1.	50389	15.84+.10 −.05	28.0, 7 cal.	3.985+.000−.005	3.96±.003
	Illum., Mk. IX-2.	64366	16.62±.0625		3.985+.000−.008	3.96±.003
3-inch.	Common, Mk. III-2.	30845	9.965±.15	5.96, 2 cal.	2.98+.00−.01	2.98±.003
	Common, Mk. III-3.	35092	9.965±.15	5.98, 2 cal.	2.99±.005	2.98±.003
	Common, Mk. III-5.	53352	9.965±.15	do.	2.985+.000−.005	2.98±.003
	Common, Mk. III-6.	54758	9.965±.15	do.	2.985+.000−.005	2.98±.003
	Common, Mk. III-7.	54759	10.035+.08 −.22	do.	2.97±.005	2.97±.003
	Common, Mk. IV.	27674	10.50±.15	7.0, 2.3 cal.	2.99±.005	2.98±.003
	Common, Mk. XII.	21513	10.90+.05 −.15	do.	2.99±.005	2.98±.003

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
2.90±.015				4.08+.003−.000	1.02±.01	4-1	4″/50, Mk. VII and VIII.
2.60±.015	1.39	33±.50		4.12+.005−.000	1.33±.01	4-4	4″/50, Mk. IX, .05 rifling.
2.60±.015				4.12+.005−.000	1.33±.01	4-4	Do.
2.75±.015				4.12+.005−.000	1.18±.01	4-7	Do.
2.75±.015	1.39	33±.50		4.12+.005−.000	1.18±.01	4-7	Do.
2.90±.05		33±.5		4.07+.005−.000	1.02±.01	4-6	4″/40.
2.90±.025	0	33±.125		4.07±.008	1.02±.01	4-11	4″/40.
2.90±.025	0	33±.025		4.07+.005−.000	1.02±.01	4-3	4″/40.
2.90±.015	0	33±.5		4.08+.005−.000	1.02±.01	4-10	4″/50, Mk. VIII.
2.65±.025		33±.5		4.08+.005−.000	1.02±.01	4-1	4″/50.
1.80±.025				3.07±.008	.70±.01	3-10	Rifling, .03 deep.
1.80±.025				3.07±.008	.70±.01	3-10	Do.
1.80±.025	.28	13±.125		3.07±.008	.70±.01	3-5	Do.
1.80±.025	.28	13±.125		3.028±.002	.70±.008	3-7	Rifling,.012 deep.
1.80±.025	.28	13±.125		3.044+.000−.004	.70±.008	3-13	Rifling, .02 deep.
2.35±.025		13±.25		3.07±.008	.70±.008	3-12.	Rifling, .03 deep.
2.73±.025		13±.25		3.07±.008	.70±.008	3-9	Do.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
3-inch.	Common, Mk. XII-1.	21236	$10.90^{+.05}_{-.15}$	7.0, 2.3 cal	2.99±.005	2.98±.003
	Common, cast iron.	21237	10.22±.05	4.892, 1.6 cal	2.99±.005	2.988±.04
	Target, Mk. III-8.	58481	9.965±.15	5.98, 2 cal	2.985+.000−.010	2.98±.003
	Target, Mk. VI.	45847	9.965±.15	do	2.985+.000−.005	2.98+.00−.01
	Target, Mk. VI-1.	38925	9.965±.15	do	2.985+.000−.005	2.98±.003
	Target, Mk. VI-2.	50442	9.965±.15	do	2.985+.000−.005	2.98±.003
	Target, Mk. VI-3.	50442	9.965±.15	do	2.985+.000−.005	2.98±.003
	Target, Mk. VI-4.	55023	9.965±.15	do	2.985+.000−.005	2.98±.003
	Shrapnel, Mk. I-1.	15758	9.70		2.97	2.97
	Shrapnel, Mk. VI.	23235	10.445±.05		2.98±.01	2.98±.003
	Shrapnel, Mk. VII.	47293	9.65		2.99+.000−.005	2.97
	Shrapnel, Mk. VIII.	47512	9.665±.01		2.97+.000−.005	2.97±.003
	Shrapnel, Mk. VIII-1.	50104	9.665±.01		2.97+.000−.005	2.97±.003
	Shrapnel, Mk. VIII-2.	53718	9.665±.03		2.97+.000−.005	2.97±.003
	Shrapnel, Mk. VIII-2.	53232	9.665±.01		2.97+.000−.005	2.97±.003
	Shrapnel, Mk. IX.	50223	9.915±.01		2.98±.005	2.98±.003
	Shrapnel, Mk. IX-1.	53719	9.915±.045		2.98±.005	2.98±.003

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
2.73±.025	....	13±.25	....	3.044±.008	.70±.008	3-4	Rifling, .02 deep.
2.0±.015	....	13	....	3.044	.75	3-16	Do.
1.80±.025	....	13±.125	....	3.07±.008	70±.01	3-8	Rifling, .03 deep.
1.80±.025	....	13±.125	....	3.07±.008	70±.01	3-10	Do.
1.80±.025	....	13±.125	....	3.07±.008	70±.01	3-10	Do.
1.80±.025	....	13±.125	....	3.07±.008	70±.01	3-5	Do.
1.80±.025	....	13±.125	....	3.07±.008	70±.01	3-5	Do.
1.80±.025	....	13+.125 −.187	....	3.07±.008	70±.01	3-10	Do.
1.35	.187	....	....	3.044±.004	.70	3-15	Rifling, .02 deep.
2.275±.025	....	13±.25	....	3.044±.004	.70±.01	3-9	Do.
1.35	.093	13±.13	....	3.044+.000−.003	.70±.01	3-6	Do.
1.35±.01	.125	13±.13	....	3.044+.000−.004	.60±.01	3-1	Do.
1.35±.01	....	13±.125	....	3.044+.000−.004	.60±.01	3-1	Do.
1.35±.02	....	13±.125	....	3.044+.000−.004	.60±.01	3-3	Do.
1.35±.01	.125	13±.125	....	3.044+.000−.004	.60±.01	3-1	Do.
1.35	....	13±.125	....	3.07±.008	.70±.01	3-5	Rifling, .03 deep.
1.35±.025	....	13±.125	....	3.07±.008	.70±.01	3-5	Do.

Characteristics of projectiles—Continued.

1	2	3	4	5	6	7
Size.	Type mark.	Drawing No.	Length.	Ogive.	Bourrelet.	Diameter base.
3-inch	Cl.B.,Mk. XIV-1	53356	10.54		2.97±.005	2.97±.003
	Flat nose, Mk. XV.	55377	10.09±.05	Flat nose	2.985+.000−.005	2.98±.003
	Flat nose, Mk. XV-1.	55376	10.09±.05	do	2.97±.005	2.97±.003
	Flat nose, Mk. XV-2.	55377	10.09±.05	do	2.985+.000−.005	2.98±.003
	Cl. B.,Mk. XVI	56198	9.915±.015		2.98±.005	2.98±.003
	Cl.B.,Mk. XVI-1	58522	9.915+.00 −.15		2.98±.005	2.98±.003
	Cl. B., Mk. XVII-1.	60289	9.915+.00 −.15		2.97±.005	2.97±.003
	Cl.B.,Mk.XX-1	Sketch 37128	9.915+.00 −.15		2.98±.005	2.97±.003
	Illum., Mk. XVIII-1.	64365	11.14±.02		2.98±.005	2.98±.003
	Illum., Mk. XVIII-2.	70062	11.14±.02		2.98±.005	2.97+.000−.003
	Illum., Mk. XVIII-3.	74068	11.14±.02		2.98±.005	2.98±.003
	Illum., Mk. XVIII-4.	74069	11.14±.02		2.98±.005	2.97+.000−.003
	Common, Mk. III-1.	66175	12.20±.05	Cup nosed	2.239+.000−.008	2.209±.003
	Common, Mk. IV-1.	66175	12.20±.05	do	2.239+.000−.008	2.209±.003
	Target, Mk. III-1.	40034	8.27±.05	5.512, 2.5 cal.	2.239+.000−.008	2.224+.000 −.006
	Common, Mk. III-3.	54901	8.45±.05	5.0, 2.2 cal.	2.239+.000−.008	2.224+.000 −.006
	Common, Mk. III-4.	64922	8.45±.05	5.6, 2.5 cal.	2.239+.000−.008	2.224+.000 −.006

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
2.2±.01	....	....	....	3.044+.000−.004	.60±.01	3-1	Rifling, .02 deep.
1.8±.025	1.23	13±.125	....	3.07±.008	70±.01	3-17	Rifling, .03 deep.
1.8±.025	1.05	13±.125	....	3.044+.000−.004	.70±.01	3-15	Rifling, .02 deep.
1.8±.025	1.24	13±.125	....	3.028±.002	.70±.01	3-11	Rifling,.012 deep.
1.35±.025	....	....	....	3.07±.008	.70±.01	3-5	Rifling, .03 deep.
1.35+.000 −.025	.75	12.6±.125	....	3.07+.008−.000	.70±.01	3-5	Do.
1.35+.000 −.025	....	12.414 ±.125	....	3.044+.000−.004	.60±.01	3-2	Rifling, .02 deep.
1.35+.000 −.025	.75	12.6±.125	....	3.044+.000−.004	.70±.01	3-14	Do.
1.8±.025	....	13±.125	....	3.07±.008	.70±.01	3-5	Rifling, .03 deep.
1.8±.025	....	13±.125	....	3.044+.000−.004	.70±.01	3-14	Rifling, .02 deep.
1.8±.025	....	13.625 ±.125	....	3.07±.008	.70±.01	3-5	Rifling, .03 deep.
1.8±.025	....	13.625 ±.125	....	3.044+.000−.004	.70±.01	3-14	Rifling, .02 deep.
1.393±.03	....	8.20±.10	....	2.263±.002	.887±.008	9 Pdr. 1	Davis.
1.393±.03	....	8.90±.10	....	2.263±.002	.787±.008	9 Pdr. 1	Do.
1.493±.015	0	6±.071	....	2.921±.004	.787±.008	6 Prd. 2	Rifling,.022 deep.
1.493±.015	.24	6±.071	....	2.921±.004	.787±.008	6 Pdr. 4	Do.
1.493±.015	.24	6±.071	....	2.921±.004	.787±.008	6 Pdr. 4	Do.

Characteristics of projectiles—Continued.

1 Size.	2 Type mark.	3 Drawing No.	4 Length.	5 Ogive.	6 Bourrelet.	7 Diameter base.
3-inch..	Common, Mk. IV.	34044	8.75+.05−.04	5.5, 2.5 cal....	2.239+.000−.005	2.224±.002
	Common, Mk. V-3.	34045	8.28+.00−.10	.....do.........	2.237+.000−.006	2.224+.000 −.006
	Steel............	19911	6.681±.05.....	4.212, 2.3 cal..	1.845+.000−.008	1.835+.000 −.008
	Common, Mk. III.	34043	6.921+.000 −.100	.....do	1.84+.000−.008	1.835+.000 −.008
	Common, Mk. IV-1.	54902	6.799±.05.....	4.612, 2.5 cal..	1.845+.000−.008	1.835+.000 −.008
	Common, Mk. II	35272	3.66+.000 −.04	3.251, 2.3 cal..	1.445+.000−.008	1.441+.000 −.008
	Common, Mk. II-1.	54875	3.56±.04......	.....do	1.445+.000−.005	1.441+.000 −.008
	Common, Mk. IV.	34041	3.89+.00−.10	.....do	1.445+.000−.008	1.441+.000 −.008
	Target Mk. V...	45846	4.30±.04......	.....do	1.445+.000−.005	1.441+.000 −.008
	Target, Mk. V...	48436	4.30±.04......	.....do	1.445+.000−.005	1.441+.000 −.008
	Target, Mk. V-1.	48668	4.30±.04......	.....do	1.445+.000−.005	1.441+.000 −.008
	Target, Mk. V-2.	62649	4.90±.04......	.....do	1.445+.000−.005	1.441+.000 −.008
	Target, Mk. VIII.	54675	3.66±.04......	.....do	1.445+.000−.005	1.441+.000 −.008
	Cl. B., Mk. VI...	53675	4.90±.04......	.....do	1.445+.000−.005	1.441+.000 −.008
	Day tracer, Mk. VII.	50946	4.90±.04......	.....do	1.445+.000−.005	1.441+.000 −.008

Characteristics of projectiles—Continued.

8	9	10	11	12	13	14	15
Band to base.	Weight of explosive.	Weight complete.	Weight of cap.	Diameter.	Band width.	No.	Gun mark.
1.743±.015	.24	6±.071	....	2.921±.004	.787±.008	6 Pdr. 1	Rifling,.022 deep.
1.493±.015	.23	6±.071	....	2.921±.004	.787±.008	6 Pdr. 3	Do.
1.185±.015	....	3.3±.043	....	1.89±.004	.767±.008	3 Pdr. 3	All 3 Pdr.
1.425±.015	.143	3.3±.043	....	1.89±.004	.787±.008	3 Pdr. 1	Do.
1.185±.015	.13	3.3±.043	....	1.898±.004	.787±.008	3 Pdr. 2	Do.
.829±.015	.026	1.057 ±.021	....	1.488+.000−.004	.731±.008	1 Pdr. 1	All 1 Pdr.
.829±.01	.026	1.057 ±.021	....	1.488±.003	.731±.01	1 Pdr. 1	Do.
1.059±.015	.026	1.057 ±.021	....	1.488+.000−.004	.731±.008	1 Pdr. 1	Do.
.60±.01	....	1.057 ±.021	....	1.488±.003	.731±.01	1 Pdr. 2	Do.
.60±.01	....	1.057 ±.021	....	1.488±.003	.731±.01	1 Pdr. 2	Do.
.60±.01	....	1.057 ±.021	....	1.488±.003	.731±.01	1 Pdr. 2	Do.
.60±.01	....	1.057 ±.021	....	1.488±.003	.731±.01	1 Pdr. 2	Do.
.829±.01	....	1.057 .021	....	1.488±.003	.731±.01	1 Pdr. 2	Do.
2.17±.01	....	1.1464 +.000 −.025	....	1.488±.003	.731±.01	1 Pdr. 2	Do.
....	....	1.1464 ±.023	....	1.488±.003	.731±.01	1 Pdr. 2	Do.

The drawing numbers listed in the above table are the numbers assigned by the Bureau of Ordnance to the manufacturing drawings.

Manufacturing drawings are based upon requisition drawings prepared by the Bureau of Ordnance. A requisition drawing shows such information as is common to all projectiles of a certain mark. This information generally includes the contour, or outside form of the projectile, the weight, the minimum volume of the cavity, the design, location and material of the rotating band, the dimensions of the base plug and fuse holes and tolerances to be allowed on the dimensions and weights of the projectiles.

A manufacturing drawing is prepared in accordance with the standard practice of the drafting room of the Bureau of Ordnance by the manufacturer as outlined in the instructions contained in Ordnance Pamphlet No. 599 (Ordnance Drafting Room Regulations) and shows all the detail dimensions of the projectile, together with the number and date of contract to which the drawing is to apply, the number of projectiles in each lot, and the number of the lot with which deliveries are to begin. After a manufacturing drawing has been approved by the bureau, a drawing number and a modification number are assigned. The title of the manufacturing drawing shows the caliber, type of projectile, and mark given in the title of the requisition drawing. The modification number does not in general indicate that there has been a departure from the requisition drawing, but it serves to identify the projectiles made in accordance with different manufacturing drawings; thus, a certain caliber Mark X modification 1 projectile indicates that the projectiles have been made in accordance with one manufacturing drawing, the Mark X modification 2 in accordance with another manufacturing drawing, and so on.

Should the design be changed by either the bureau or the manufacturer, the manufacturing drawing is revised by the manufacturer in accordance with the standard practice of the drafting room of the Bureau of Ordnance. Should the change be slight, the bureau may assign a new modification number in order to identify the projectiles in which the change has been incorporated, but if the change is radical, the bureau may assign a new mark and modification number. In case of any change whatsoever in the design of the projectiles, the manufacturer must submit the revised drawing or the new drawing, if one is made for approval, which must show the date and reference number of the bureau's letter authorizing or directing the change and the lot numbers to which the change will apply. In case a new drawing is submitted, the number of the drawing to be susperseded must be shown in the new drawing.

Chapter XI.

CARTRIDGE CASES AND CASE AMMUNITION.

1. In the design and preparation of ammunition for service use, consideration must be given to the ease, facility, and rapidity of loading, the safety of the personnel, and the cost of manufacture and preparation. When the whole charge, including the projectile and primer, can be loaded in one operation, greater rapidity of fire is possible than when loading the projectile and powder separately. When the powder is protected, as in a cartridge case, the danger from flarebacks is greatly reduced. However, as the cartridge case contains the powder charge and primer, additional care must be exercised in handling, for if a sharp edge strike the primer it will explode, and thus ignite the charge.

2. The ammunition for the smaller guns is made up with the powder and primer put up in brass cartridge cases, which are hollow cylinders with flat heads, shaped to fit the bore, those for certain new guns being bottle necked. For ease in loading, the limit for modern, high-powered guns is placed at the 4″/50. Above this it is necessary to split up the charge, so as to load the powder and projectile separately, with certain exceptions to be mentioned later. Besides affording a convenient method of loading, the cartridge case performs the very important function of preventing the escape of gases through the breech. The cartridge case is a fairly snug fit in the chamber and on expansion, due to firing, makes a gas seal. Some military forces, notably the German Navy, utilize this method of gas checking in practically all guns, but in our naval service, due to difficulties in handling large cases, especially in disposing of the empties, another system is used. The cartridge case in the larger caliber guns is eliminated and the powder is put up in silk bags. The gas checking is obtained by the mushroom and pads on the breech plug, and the primer is fired by a lock fixed in the breech plug. Were cartridge cases used in all sizes of guns, with very large charges it would be necessary to put up part of the charge in a case and part in silk bags or thin brass cylinders, as was done in the German Navy, but this complicates the loading. With case guns, gas ejector systems are not necessary, but they are absolutely necessary with bag guns. Cartridge cases.

3. Cartridge cases are manufactured by drawing out blanks of special cartridge case metal. The general features of the manufacture of the different types are the same except for those used in the Davis gun. The metal is cast in slabs of a composition approximately 70 per cent copper and 30 per cent zinc. It is scraped, annealed, and rolled out to the proper thickness and disks are stamped out to form the blanks, the disks being made of a sufficient diameter to allow for drawing the material out into the finished case. The first operation (Fig. 33) is performed in a Manufacture of cases.

press with a suitable die to form the cup. Successive drawing operations are then carried on and the cup gradually assumes the general form of a cartridge case. The number of drawing operations depends on the size of the case being made. After each two draws, as a general rule, the strains in the metal are relieved by annealing. When the blank has been drawn out to the proper length, the open end is trimmed off and the head is then formed in one operation by the action of suitable dies in a press. When finishing off, to give the bottle-neck effect, three additional drawing operations are required with a change of dies. The case is then finish machined, the primer hole drilled and tapped out, if for a screw primer, and finally the case is carefully gauged, special attention being paid to its fit in a standard chamber gauge and to the centering of the primer hole.

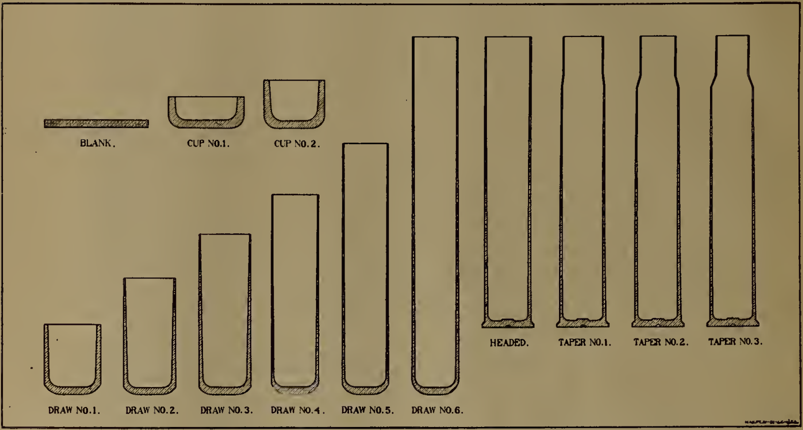


Fig. 33.—Operations for making 4-inch 50 Caliber Cartridge Cases.

Care of cartridge cases. 4. Cartridge cases are reloadable and consequently must be given considerable care so that when returned to an ammunition depot they may be prepared for reissue. They must be kept free from salt, moisture, oil, and grease at all times, whether empty or loaded. They should be placed standing on the heads when empty and not on their sides. After firing they should be deprimed, washed thoroughly with hot water and soapsuds, and repacked carefully in the cartridge boxes or tanks in which issued. On receipt at an ammunition depot they are cleaned, reformed, gauged, inspected, primed, and are then ready for loading for reissue. (See ch. 1, pars. 10 and 12.)

5. The following list shows the various cartridge cases to be found in service:

No.	Plate No.	Caliber.	Use.	Bureau of Ordnance drawing No.
1	VIII	1-Pdr	Saluting	57973
2		do	Service	13095
3	IX	3-Pdr	Saluting	38642
4		do	Service	13096
5	X	6-Pdr	Saluting	38642
6		do	Service	
7		do	Nonrecoil	54857
8	XI	3″/23 F. G	Saluting	57875
9		do	Service	
10	XII	3″/23 L. V	Saluting	57875
11		do	Service	
12	XIII	6 and 9 Pdr	Service (nonrecoil)	15515
13		3-inch	do	
14	XIV	3″/50	Saluting	45498
15		do	Service	
16	XV	4″/40	do	
17		4″/50	do	
18		5″/40	do	
19		5″/51	do	
20		6″/40–45	do	

Care in handling.

6. *Caution.*—In loading case guns, care should be exercised that the point of a projectile held by one loader will not accidentally strike the primer in the base of the cartridge in the hands of another loader. Projectiles should not be loosened in a case, as on loading they may slip out and jam.

This is especially liable to happen with some semiautomatic guns, where the rotating band is held by the rifling and the case rebounds and is jammed by the ascending plug, usually distorting the case.

Case ammunition; types.

7. Plate 8 shows the assembly of 1-pounder ammunition. Figure 1 is the saluting ammunition; Figure 2 is the assembly with service projectile, either nose or base fused; and Figure 3 shows the assembly of day tracer ammunition for antiaircraft guns.

Plate 9 shows the assembly of 3-pounder ammunition, Figure 1 the saluting and Figure 3 the service charges. Target practice ammunition is the same except for the loading of the projectiles, Figure 3.

Plate 10 shows the assembly of 6-pounder saluting and service ammunition. Target ammunition is the same except for the loading of the projectiles.

Plate 11 shows the assembly of 3″/23 F. G. ammunition.

Plate 12 shows the assembly of 3″/23 L. V. ammunition for the 3″/23 guns in use for submarine and antiaircraft work. For antiaircraft use, these cartridges are crimped and assembled without wads and distance pieces.

Plate 13 shows the assembly of Davis gun ammunition, 6-pounder, 9-pounder, and 3-inch.

Plate 14 shows the assembly of 3″/50 ammunition with different types of projectiles used.

Plate 15 shows the assembly of 4″/50 ammunition with different types of projectiles used.

Cartridge tanks and boxes: variety of types.

8. Case gun ammunition is issued in special tanks and boxes for safe transportation and stowage. Each type of ammunition has its own box or tank, and each ship has the magazines arranged for the standard tank or box which goes with the battery. It is important to note that different types of projectiles have nose blocks to fit, and should it be necessary to restow ammunition that has been removed from the containers, care should be exercised that cartridge cases are returned to the proper tanks or boxes, in accordance with the proper markings, and that the same blocks are used as were originally issued. This provision is more important now that ready service boxes are provided at guns for the stowage of untanked or unboxed cartridges.

Number of cartridges in tanks or boxes.

9. As many cartridges are packed in a container as will allow easy handling.

4 inches and above	**1 per box.**
3″/50	**4 per box.**
3″/23	**6 per box.**
3″/23	**7 per box.**
6-pounder	**11 per box.**
6-pounder	**7 per box.**
3-pounder	**16 per box.**
1-pounder antiaircraft	**100 per box.**
1-pounder	**60 per box or tank.**

10. The 1-pounder ammunition box, Mark II, is shown in Figure 34. It has a transom with openings for 60 cartridges. The bottom of the box has a recess cut corresponding to each opening in the transom, and the top has a recess for

PLATE VIII.

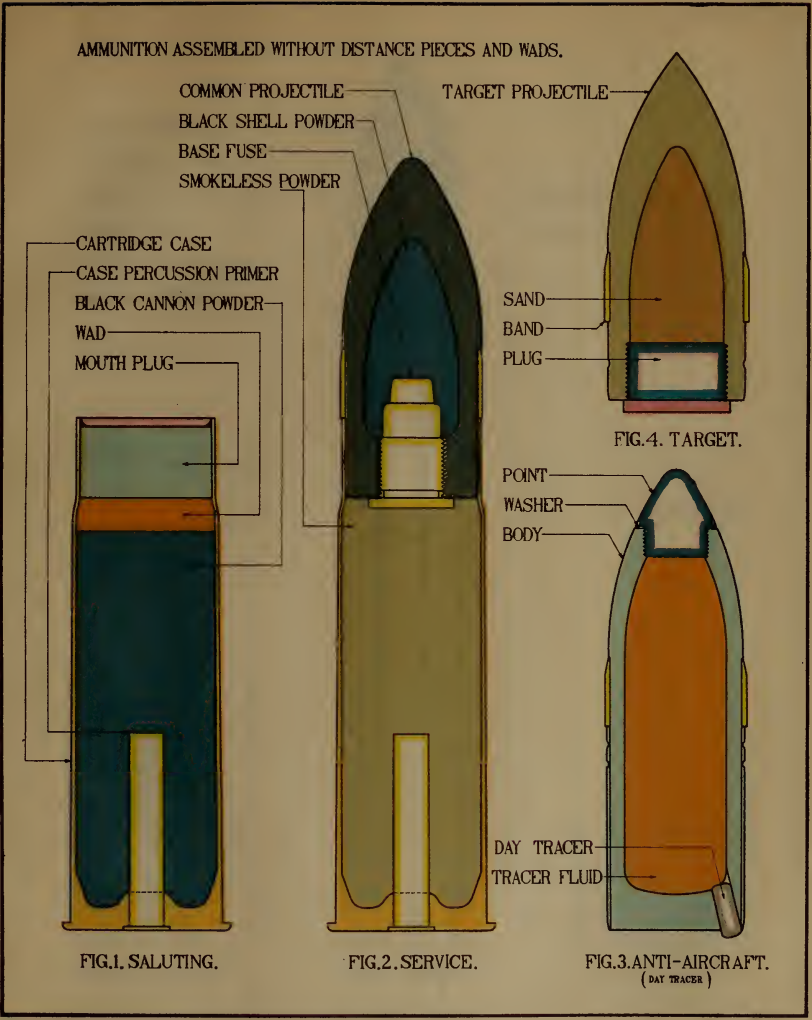


FIG.1. SALUTING.

FIG.2. SERVICE.

FIG.3. ANTI-AIRCRAFT. (DAY TRACER)

FIG.4. TARGET.

1-Pdr. Ammunition.

PLATE IX.

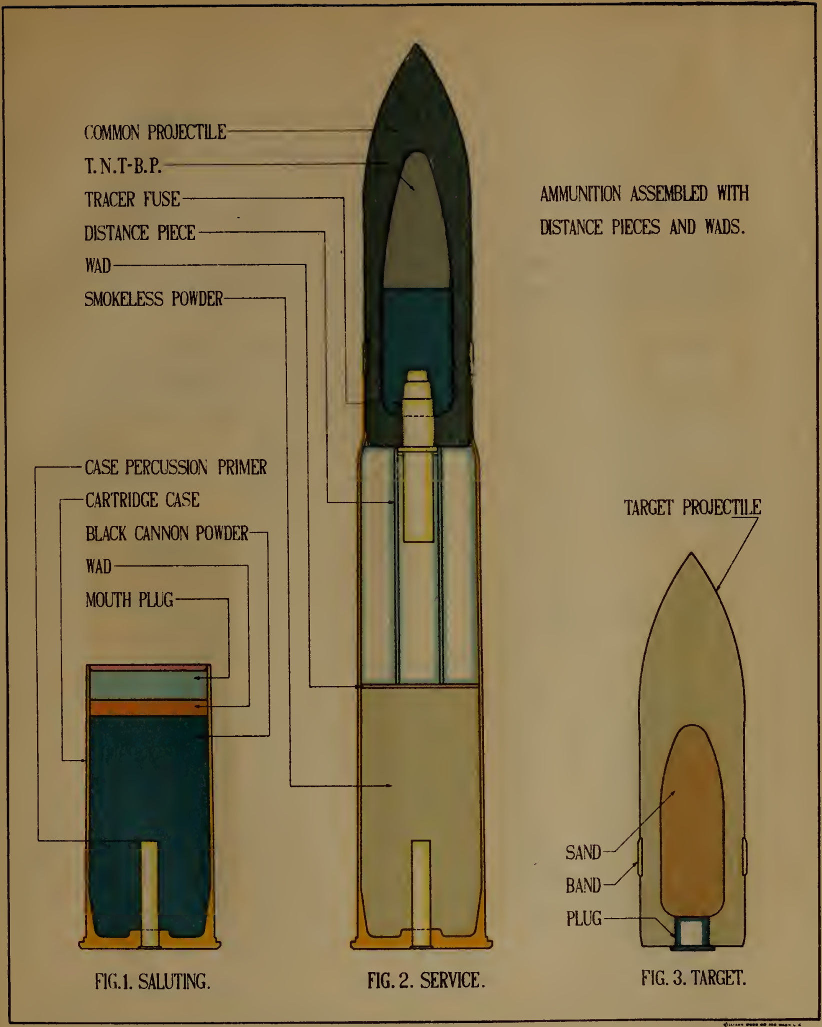


FIG. 1. SALUTING.

FIG. 2. SERVICE.

FIG. 3. TARGET.

3-Pdr. Ammunition.

PLATE X.

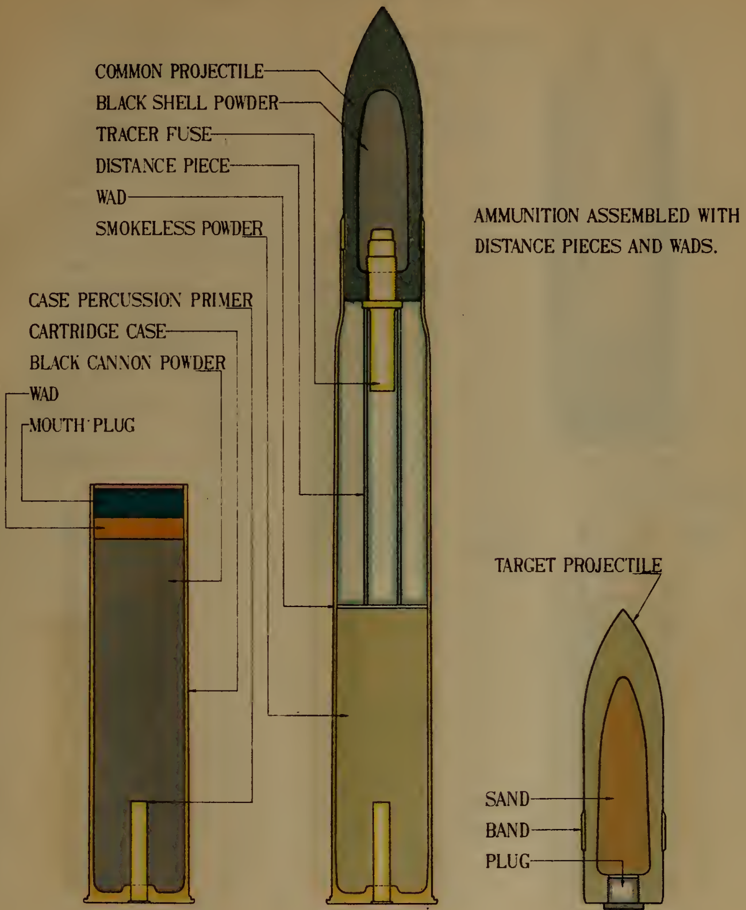
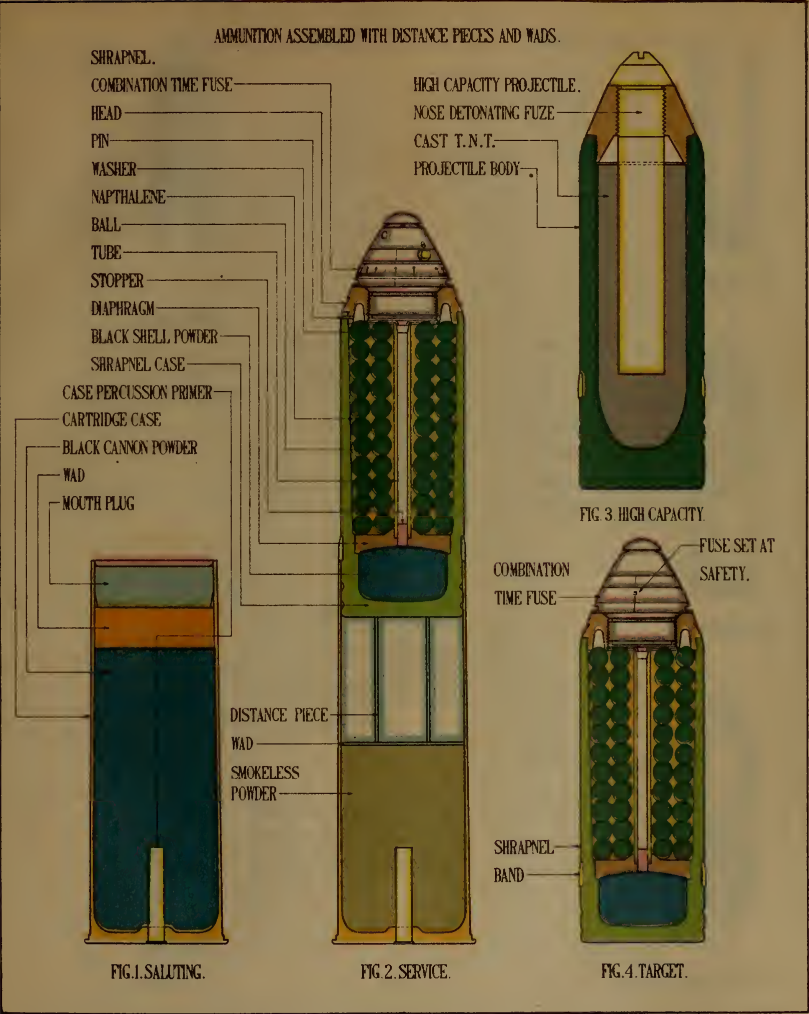


FIG.1. SALUTING.   FIG.2. SERVICE.   FIG.3. TARGET.

6-Pdr. Ammunition.

PLATE XI.



3-Inch 23 Caliber Landing Gun Ammunition.

PLATE XII.

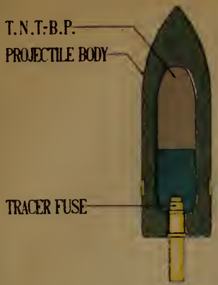


FIG. 1. COMMON.

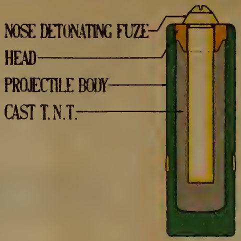


FIG. 2. FLAT NOSE.

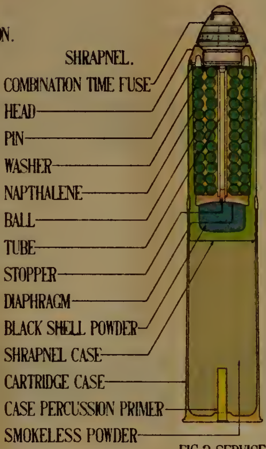


FIG. 3. SERVICE.

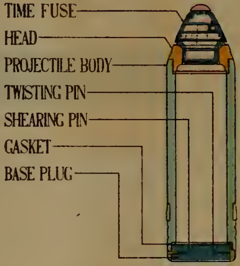


FIG. 4. ILLUMINATING.

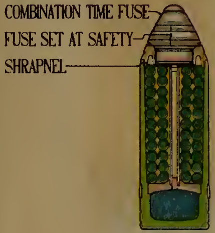


FIG. 5. TARGET.

AMMUNITION ASSEMBLED WITHOUT DISTANCE PIECES OR WADS, AND TO BE THOROUGHLY CRIMPED BEFORE ISSUE.

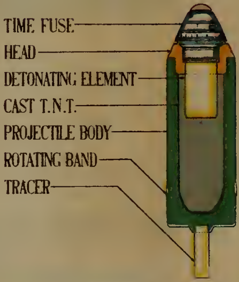


FIG. 6. CLASS B. ANTI-AIR CRAFT.

3-Inch 23 Caliber Landing Gun Ammunition.

PLATE XIII.

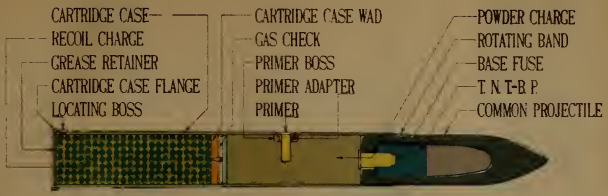


FIG. 1. 6 POUNDER.

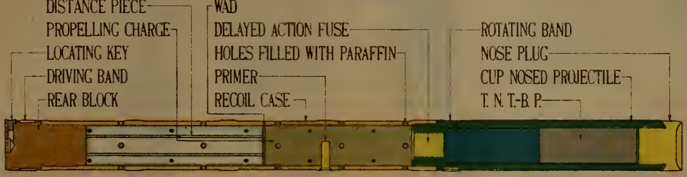


FIG. 2. 9 POUNDER.

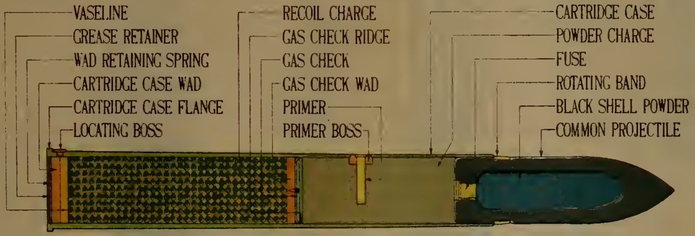


FIG. 3. OLD 3 INCH.

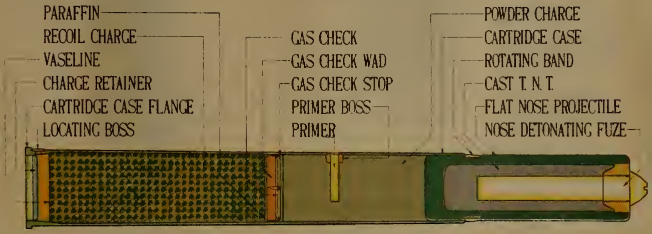


FIG. 4. NEW 3-INCH.

Davis Gun Ammunition.

PLATE XIV.

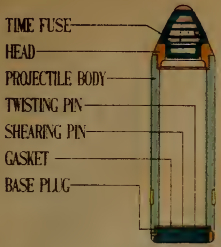


FIG. 1. ILLUMINATING.

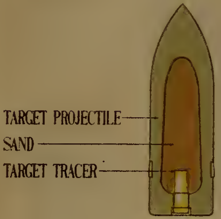


FIG. 3. TARGET.

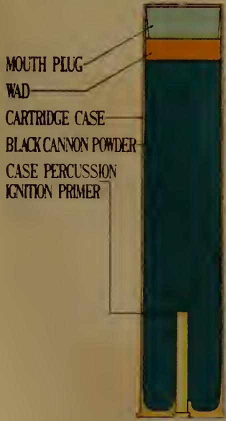


FIG. 6. SALUTING.

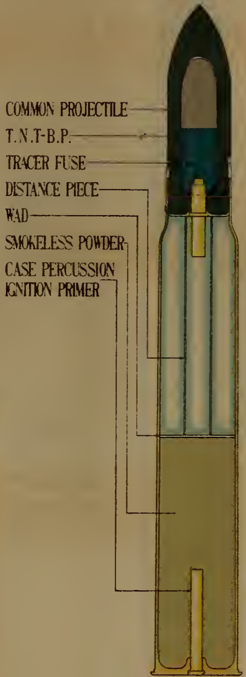


FIG. 4. SERVICE.

AMMUNITION ASSEMBLED WITH DISTANCE PIECES AND WADS.

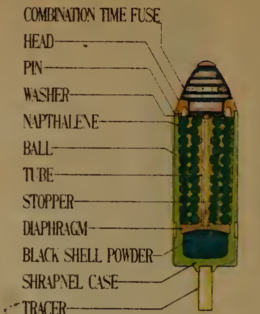


FIG. 2. SHRAPNEL.

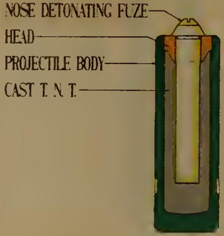


FIG. 5. FLAT NOSE.

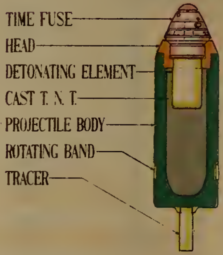
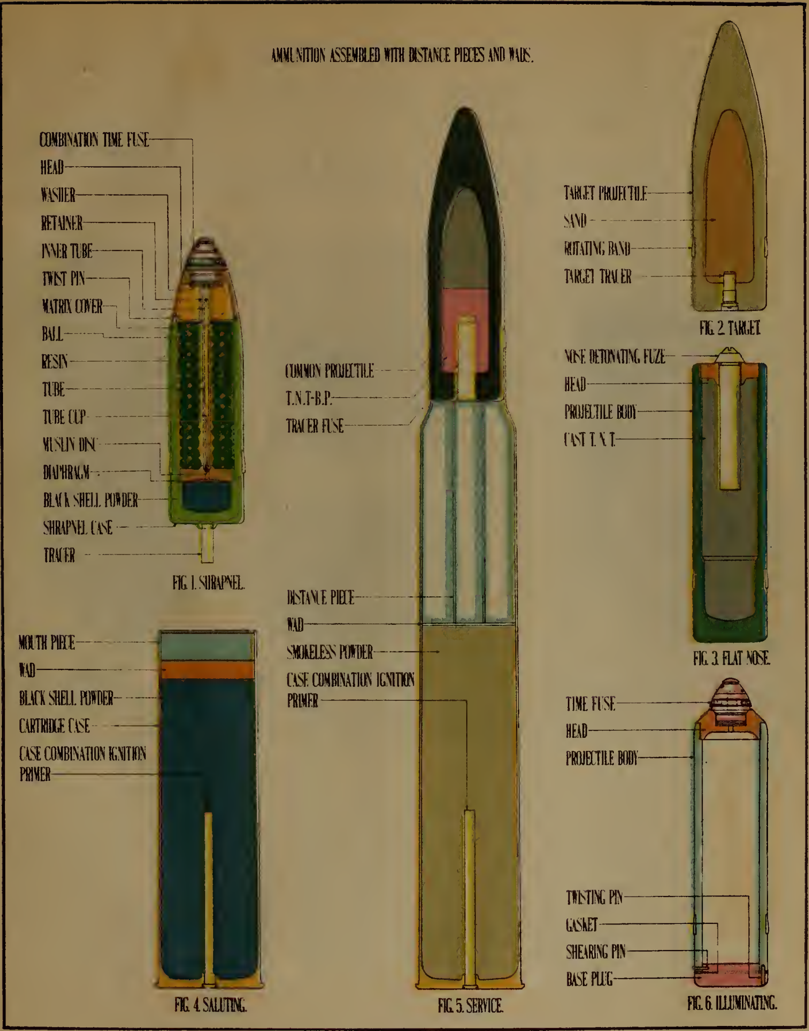


FIG. 7. CLASS B. ANTI-AIRCRAFT

3-Inch 50 Caliber Ammunition.

PLATE XV.



4-Inch 50 Caliber Ammunition.

the protection of the primer. Figure 34 also shows the special box, Mark III, for antiaircraft 1-pounder guns. This box is designed to take a belt in which 100 cartridges have been loaded. The belt is faked down in layers. The 6-pounder Mark I cartridge tank is also arranged to hold the cartridges by means of a transom in a manner similar to the 1-pounder box, the projectiles resting on the bottom in recesses.

11. The 3″/23 tank, Mark I, Figure 35, is designed to hold seven 3″/23 cartridges. It is designed to be air and water tight, especially for submarines armed with 3″/23 guns. In this tank the nose of the projectile is not resting on the bottom, but the weight of the cartridge is taken on the lower diaphragm of the transom in order to protect the nose fuse. The transom may be lifted out of the tank by a bail. In case the projectiles pass so far through the lower diaphragm that the rotating band comes up against the center diaphragm, the casing will be distorted. To prevent this, special cups are sometimes used to fit the lower diaphragm to carry the weight of the cartridge. Frequent inspections should be made to see that the fuse covers are not becoming loose, and if so, the ammunition should be turned in for overhaul.

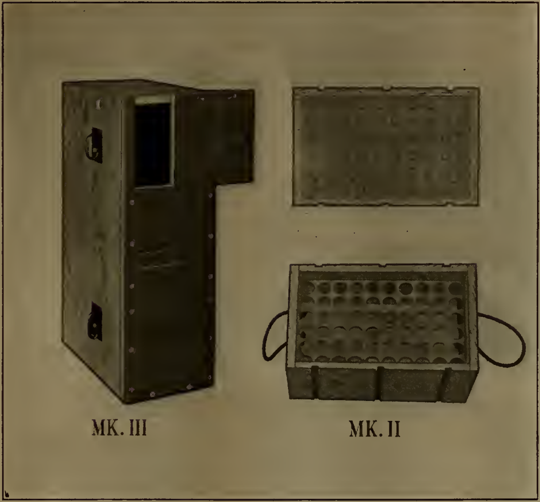


Fig. 34.—1-Pounder Amm. Boxes Mks. II and III.

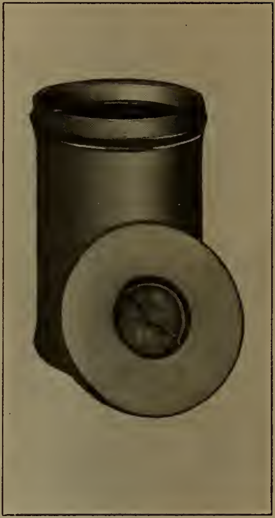


Fig. 35.—3″/23 Cartridge Tank Mk. I.

12. The 3″/23 field and landing gun ammunition boxes, Mark IV and Mark IV Mod. 1, respectively, Figure 36, are similar in construction except as to length, the latter being longer than the former. Special nose blocks are required for common projectiles, shrapnel, and illuminating projectiles.

13. The 3″/50 caliber ammunition box, Mark I Mod. 1, Figure 37, is the one usually met with in service. It holds four cartridges and has special nose blocks for different type projectiles. It is to be noted in this box that the projectiles do not all point the same way. The Mark I Mod. 2 differs from the Mod. 1 in that two sides are sheet metal instead of wood. This type is designed to fit the 5-inch hoists on battleships. The covers are secured by metal straps covered with marline.

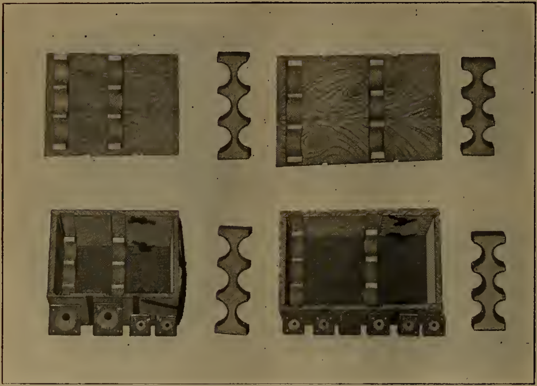


Fig. 36.—3″/23 Amm. Boxes Mk. IV and IV Mod. I.

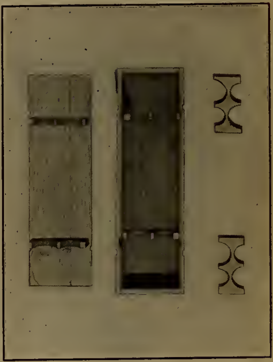


Fig. 37.—3″/50 Amm. Box Mk. I, Mod. I.

14. The Mark II, 3″/50 tank, Figure 38, is especially designed for submarines armed with 3″/50 guns. It is constructed so as to be water and air tight. The weight of the cartridge is taken up by the rotating band resting on a diaphragm. A special lifting wrench is provided for extracting the cartridges.

15. Figure 39 shows the 4″/40 caliber box. This is used for 3″/50 illuminating projectiles.

16. Figure 40 shows the 4″/50 cartridge tank as issued to destroyers, submarines, and certain other vessels whose stowage arrangements are designed to take this type. The diaphragm supporting the case by the rotating band of the projectile causes the cartridge to spring up so that it may be withdrawn. It is kept down in place by a cork portecting pad on the inside of the cover. The top of this type frequently stick, and difficulty is experienced in opening them. A special opening tool is issued with two lugs on the handle for turning the butterfly

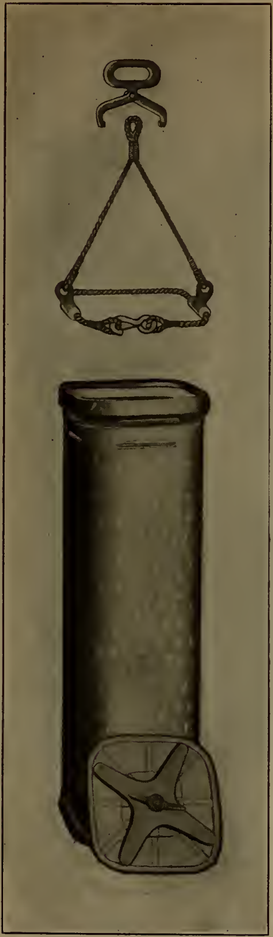


Fig. 38.—3″/50 Amm. Tank, Mk. II, with extractor.

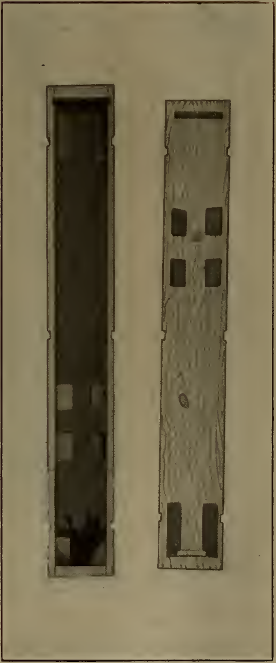


Fig. 39.—4″/40 Amm. Box also used for 3″/50 Ill. projectile.

nut and an open jaw for prying up the top. It should be rested on one of the side lugs.

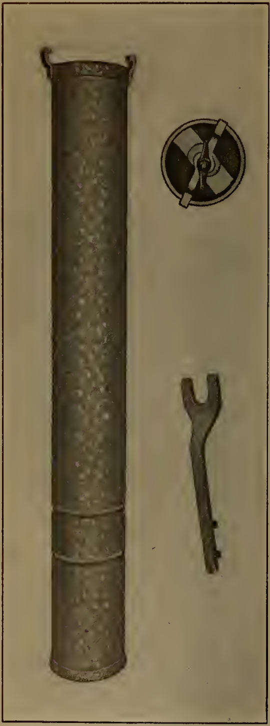


Fig. 40.—4″/50 Cartridge tank Mk. II.

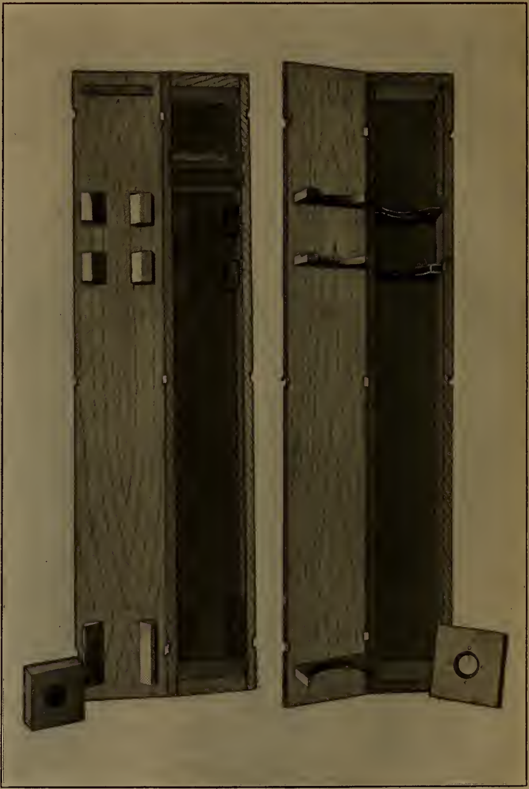


Fig. 41.—4″/50 Cartridge Boxes Mk. III and III Mod. 1.

17. Figure 41 shows the 4″/50 cartridge boxes special nose blocks are required for each type of projectile.

18. Figure 42 shows the 6″/40 ammunition box. It holds one cartridge case without a projectile.

19. Figure 43 shows a group of miscellaneous packing boxes.
(1) Galvanized iron box for Mark VIII primers.
(2) Cabinet box, wood, for Mark I containing detonators.
(3) Copper box for Mark XIV primers.
(4) B. L. R. combination primers.
(5) Tin box for Mark I detonators.
(6) Copper box for B. L. R. primers containing wood block.

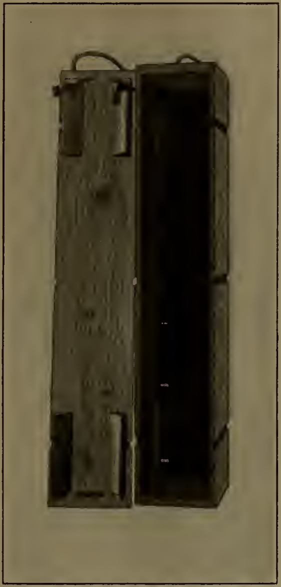


Fig. 42.—6″/40 Amm. Box. Mk. II.

(7) Percussion detonators for torpedoes.
(8) Tin box for electric detonators (new type).
(9) B. L. R. combination primers.
(10) Packing box for Mark XIII primers.

20. Bag charges are issued to the service in special metal tanks made air-tight. Formerly these tanks were made of copper sheets with brass or bronze top and bottom rings, the tank bodies being protected by thin wood strips riveted along

Powder tanks.

the sides. The latest practice is to use thin sheet steel rolled and welded into a cylinder. The metal is protected by an antirust coating, such as galvanizing or parkerizing, and then the interior is coated with an antiacid paint.

Importance of air-tight tanks. 21. Powder tanks are a very important item of the ordnance equipment, for on the efficiency of each tank rests the responsibility of the regularity of the powder.

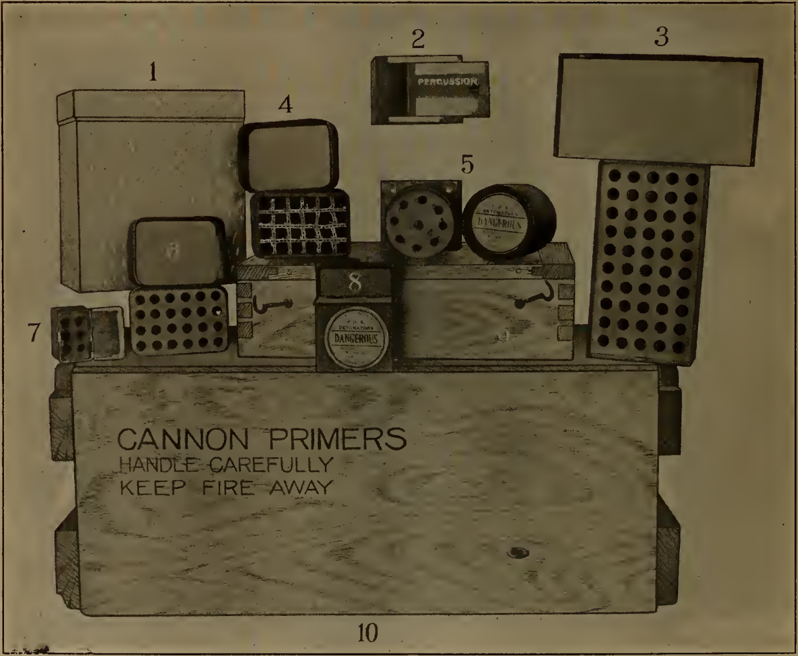


Fig. 43.—Misc. Packing Boxes for primers and detonators.

The methods in use for prolonging the life of smokeless powder is set forth in chapter 5. It must be borne in mind, however, that the stabilizer only prolongs the life and does not prevent deterioration under adverse storage conditions. As explained in chapter 1, if a powder tank is leaky, the solvent escapes and the ballistic properties of the powder change. The length of time the powder is exposed to this condition, and the size of the leak, affect the amount of change. It so happens that certain charges thus treated give varying results and have a vital and immediate effect on the dispersion. The answer is: See that the powder tanks are kept air-tight. All tanks now issued to service have rubber gaskets in the covers which must be maintained in an efficient condition. There are several types of closures in use, either a system of dogs and nuts fitted outside of cover or else contained in the cover, or, as in the latest make of 16-inch tank, a cam system. The self-contained tops are considered the best, as they do not offer projections which may be struck and loosened. When tanks are accepted they are tested under a pressure of 5 pounds of air for three minutes.

22. Powder tanks must be as light as is consistent with strength, capacity, serviceability and air-tightness in order that a vessel may not carry around a mass of useless material. They must be so arranged as to permit quick opening, as the number of loaded tanks allowed open at one time is limited by the safety precautions. Tanks are designed to hold the largest fraction of a charge consistent with ease in handling and stowage. The number of tanks to a charge varies with the caliber, as will be seen by reference to the following table:

TABLE "A."

Gun.				Powder tank.			
1	2	3	4	5	6	7	8
Caliber.	Minimum length of powder space (inches).	Diameter of choke (inches).	Maximum weight of charge (pounds).	Minimum inside length (inches).	Minimum inside diameter (inches).	Number tanks per charge.	Number sections per tank.
5″/50	31.73	6.25	23	30.0	6.5	1	1
5″/51	35.73	6.55	27	30.4	6.5	1	1
6″/50	41.08	7.25	42	41.0	7.2	1	1
6″/53	47.80	7.25	50	47.8	7.2	1	1
7″/45	51.16	8.50	62	26.0	8.5	2	1
8″/35	42.18	9.50	47	45.0	9.3	1	2
8″/45	56.34	9.50	104	28.8	9.5	2	1
10″/30	55.35	12.50	95	30.0	12.5	2	1
10″/40	67.28	12.50	220	34.2	12.5	2	1
12″/35	72.49	14.50	168	38.0	14.5	2	2
12″/40	81.45	14.50	285	40.3	14.5	2	2
12″/45	81.00	14.50	310	40.3	14.5	2	2
12″/50	81.97	14.50	353	40.3	14.5	2	2
13″/35	78.76	15.50	204	41.3	15.5	2	2
14″/45	81.08	15.50	380	40.1	15.0	2	2
14″/50	92.21	15.50	480	40.1	15.0	2	2
16″/45	94.03	17.50	600	37.28	17.0	2½	2
16″/50	113.78	17.50	720	37.28	17.0	3	2
18″/48	115.525	19.50	840	29.00	17.5	4	2

TABLE "A"—Continued.

Powder charge.				Ignition.		
9	10	11	12	13	14	15
Number sections per charge.	Maximum length per section (inches).	Maximum diameter per section (inches).	Type.	Total ignition (grams).	Ignition per section (grams).	Diameter ignition circle (inches).
1	29.25	6.0	Unstacked	75	75	5.5
1	30.00	6.3	.....do	75	75	5.5
1	40.00	6.9	.....do	100	100	6.0
1	47.00	6.9	.....do	150	150	6.0
2	24.00	8.0	.....do	300	150	6.5
2	20.00	8.5	.....do	300	150	7.0
5	27.70	9.1	.....do	400	200	7.0
2	26.00	11.5	.....do	400	200	9.0
2	33.00	12.1	.....do	800	400	9.0
4	17.00	13.5	.....do	1,000	250	10.0
4	19.00	13.5	.....do	1,200	300	10.0
4	19.50	13.8	Stacked	1,200	300	10.0
4	19.50	13.5	.....do	1,200	300	10.0
4	19.00	13.5	Unstacked	1,000	250	10.0
4	19.50	14.0	Stacked	1,200	300	10.0
4	19.90	14.6	.....do	1,200	300	10.0
5	18.25	16.5	.....do	1,750	350	10.0
6	18.50	16.5	.....do	2,100	350	10.0
8	14.20	16.5	.....do	2,400	300	10.0

The inside of a powder tank must have a surface so coated that it will not exert any deleterious effect on the powder. Special handling facilities are fitted for handling tanks, either handles on the sides, or lugs for using special slings. Tanks should never be rolled on deck or jumbled around in cargo nets, as this always results in leaks developing.

23. The following tanks are selected for illustrations, as they represent the different types in service:

Figure 44, 5-inch powder tanks.
Figure 45, 12-inch powder tanks.
Figure 46, 14-inch powder tanks.
Figure 47, 16-inch powder tanks.

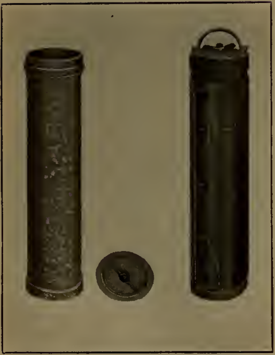


Fig. 44.—5″ Powder Tanks.

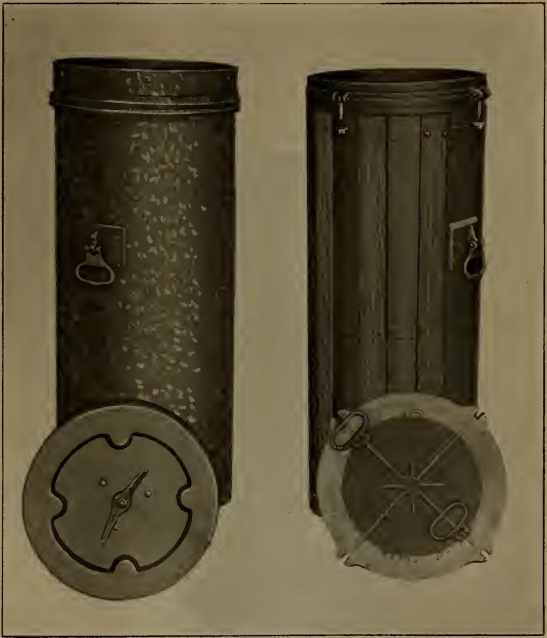


Fig. 45.—12″ Powder tanks.

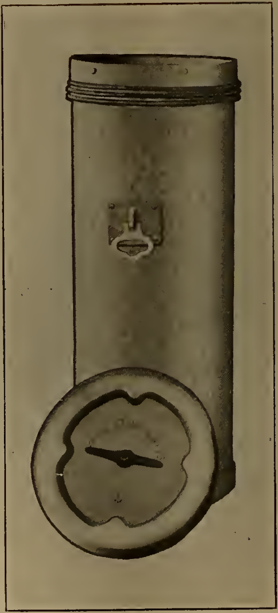


Fig. 46.—14″ Powder Tank.

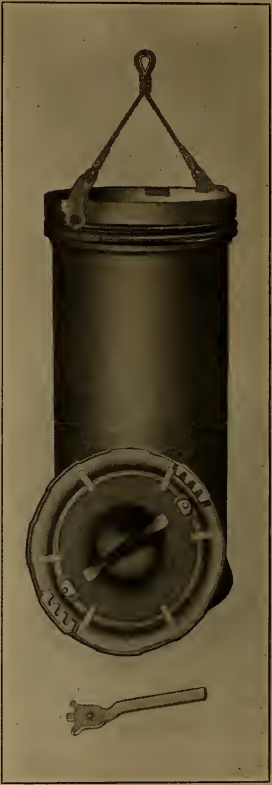


Fig. 47.—16″ Powder Tank.

Chapter XII.

FUSES AND TRACERS.

Nomenclature.

1. A fuse for use in projectiles is a device for causing the burster charge to explode when certain conditions have been fulfilled. A recent act of Congress makes the following distinction between the various kinds of fuses for regulation of their transportation by commercial carriers, as further regulated by Rules of Interstate Commerce Commission.

"Fuze" (spelled with a "z"): A fuze is used to detonate a high explosive burster charge for projectiles, mines, bombs, etc. It is commonly called a detonating fuze.

"Fuse" (spelled with an "s"): A fuse is used to ignite the burster charge of a projectile or to convey fire to an explosive slowly, as in blasting work. For a projectile, these are commonly called ignition fuses.

"Fusee": A pyrotechnic night signal used by steamboat and railroads.

"Primer": A device used to ignite the propelling powder charges of ammunition.

The distinction made above between "fuses" and "fuzes" will be used in the Navy only as applying to shipment by commercial carriers. For other purposes the term "fuse" will be used for all classes of fuses.

For Navy material the following designations are used:

Detonating fuze, Mark — Mod. —.
Ignition fuse, Mark — Mod. —.
Superheater fuse, Mark — Mod. —.

List of fuses.

2. The following table comprises a list of the fuses which may be found in service:

IGNITION FUSES.

NOTE.—Fuses will be designated by caliber and mark. The mark will be that which is stamped on fuse, thus: "Ignition fuse, minor cal., Mark III." Only those ignition fuses which are used by the Navy are listed.

Mark and mod.	Description of fuse.	Marking on fuse.	
		Words or letters.	Mark.
I	Navy base, major caliber	Year of manufacture	
I-1	do	do	
I-2	do	do	
I-3	do	do	
I-4	do	do	
II	Navy base, minor caliber, short	W. N. Y. and year of manufacture.	
II-1	Navy base, minor caliber, long	do	
II-2	Broderick, minor caliber	C. M. B.-J	
II-3	Hotchkiss, minor caliber, R.H. thread.	Hotchkiss	

Ignition fuses—Continued.

Mark and mod.	Description of fuse.	Marking on fuse.	
		Words or letters.	Mark.
II-4	B. O. C. minor caliber, coarse, L. H. thread.	B. O. C	III
II-5	Driggs, minor caliber, R. H. thread.	U. M. C. Co., Bridgeport, Conn., Driggs.	
II-6	Hotchkiss, minor caliber, standard thread.		
II-7	Driggs, minor caliber, standard thread.	U. M. C. Co., Bridgeport, Conn., Driggs.	
II-8	Wilson-Chase, minor caliber	Manufactured by U. S. Ordnance.	
II-9	Baldwin, minor caliber	B	
III	Merriam, major caliber	Model 1903, Merriam	
IV	Wilson-Chase, major caliber	Wilson, W. C	
IV-1	do		
IV-2	do	Manufactured by U. S. Ordnance Co.	
IV-3	Wilson-Lynch, major caliber	1905	
V	Watson, major caliber	Watson fuse, 1904	V-1
V-1	Watson, medium caliber	Watson-Fostoria	V-1
VI	12-sec., Bethlehem, combination.	Bethlehem, 1905	
VII	15-sec., Frankford Arsenal combination.	Scovill Manufacturing Co., 1898	
VIII	Semple base, minor caliber	Semple, 1907	
VIII-1	Semple battle tracer	Semple battle tracer	
VIII-2	Semple, minor caliber (friction tracer).	Semple tracer fuse	S. C. Mk. II
VIII-3	Semple, minor caliber (percussion tracer).	do	III
VIII-4	Semple, minor caliber tracer	do	III
VIII-5	Semple type, minor caliber base	N	XII
VIII-6	do	A. M. Co	XII-1
IX	23-sec., Frankford Arsenal combination (oil model).		
IX-1	21-sec., F. A. C., model 1907	F. A., model 1907	
IX-2	21-sec., F. A. C., model 1907 M	F. A. C., model 1907	
IX-3	21-sec., F. A. C., model 1915		
X	Semple, medium caliber (friction tracer).	Semple tracer fuse	I
X-1	Semple, medium caliber (percussion tracer).	do	II
X-2	Semple, medium caliber tracer (1½-inch threads).	do	III
X-3	Semple, medium caliber tracer	do	IV
X-4	do	do	IV-A
X-5	Semple base, medium caliber	Semple Neptune	X-5
X-6	do	do	X-5
X-7	do	do	X-5
X-8	do	do	X-5
X-9	Semple type, medium caliber tracer.	G. D. tracer fuse	XIII
XI	21-sec., combination, W. N. Y	Fuse, W. N. Y	XI
XI-1	21-sec., combination, Scovill	Fuse, Scovill	XI-1
XI-2	21-sec., time, Scovill	do	XI-2
XI-3	21-sec., time, Scovill	do	XI-3
XI-4	21-sec., combination, Scovill	do	XI-4

Ignition fuses—Continued.

Mark and mod.	Ammunition to which assigned.	Manufactured by—	Remarks.
I		Naval Gun Factory	All major caliber Navy base fuses are being withdrawn from service and held in store under an obsolete classification, to be used only in case of a failure in the supply of centrifugal fuses.
I-1			
I-2			
I-3			
I-4			
II	1-pounder	do	
II-1	do	do	
II-2	do	C. M. Broderick	
II-3		Hotchkiss Manufacturing Co.	Suitable for use in minor caliber shell fitted to take these fuses.
II-4		British Ordnance Co	
II-5		U. M. C. Co	Do.
II-6	1-pounder	Hotchkiss Manufacturing Co.	
II-7	do	U. M. C. Co	
II-8	do	U. S. Ordnance Co	
II-9	All minor caliber	Ansonia Manufacturing Co.	
III	4″/40, 5″/40, and 6″/40	Merriam	Practically all reloaded at Washington Navy Yard, 1915 to 1919. Remainder reserved at depots for reloading, in case bureau sees fit to order them reloaded in the future.
IV	do	Wilson-Chase	
IV-1	do		
IV-2	do	U. S. Ordnance Co	
IV-3	do	Wilson-Lynch	"R" stamped on fuse indicates it was reloaded at Washington Navy Yard.
V	4″/40, 5″/40, 6″/40, 8″/35.		
V-1	All medium caliber	Fostoria Screw Co	Do.
VI	3-inch F. G. and L. G	Bethlehem Steel Co	To be used in target practice.
VII	do	Scovill Manufacturing Co.	Do.
VIII	1-pounder		All Semple minor caliber fuses may be considered as suitable for all minor caliber ammunition, but the Mark III fuses are preferred for 3″/50 caliber ammunition.
VIII-1	do		
VIII-2	do	J. B. Semple Co	
VIII-3	1, 3, and 6 pounder, and 3″/50.		
VIII-4	do and 3″/50.		
VIII-5	All minor caliber	Nathan Manufacturing Co.	
VIII-6	1-pounder only	Ansonia Manufacturing Co.	
IX	Broadside shrapnel	Frankford Arsenal	
IX-1	do	do	

Ignition fuses—Continued.

Mark and mod.	Ammunition to which assigned.	Manufactured by—	Remarks.
IX-2	All ammunition fitted for time fuses.	Frankford Arsenal	
IX-3		do	
X		J. B. Semple Co.	All Semple medium caliber tracer fuses may be considered as suitable for all shell fitted to take major caliber ignition fuses, but the Mark IV and IV-A fuses are preferred for high powered 5″/51 and 4″/50 Mark IX ammunition.
X-1		do	
X-2		do	
X-3		do	
X-4		do	
X-5	All medium caliber	Neptune Meter Co	
X-6	do	do	
X-7	do	do	
X-8	do	do	
X-9	do	Gray & Davis	Semple fuse plunger, G. & D. tracers.
XI	All ammunition fitted for time fuses.	Naval Gun Factory	
XI-1	do	Scovill Manufacturing Co.	
XI-2	3″/50 A. A. ammunition only.	do	Similar to Mark XI-1, but with percussion element omitted.
XI-3	do	do	Do.
XI-4	All ammunition fitted for time fuses.	do	

Early history. 3. The gradual development of fuses for military purposes from the earliest times, subsequent to the use of solid shot, has been affected by changes in guns, projectiles, and explosives, and by changes in and requirements for their tactical uses. The first projectiles used were round stones. These were followed by solid round shot which were succeeded by hollow round shot. The advantage of fragmenting the hollow shot was apparent, and for this purpose a burster charge of black powder was used. At first the methods for exploding the burster charge were very crude. A piece of fusee was placed in a hole in the shot and either ignited first by a spark before firing, or by the flame from the powder charge. With the low-powered cannon of the times, the short ranges and the low velocity, the fuse kept burning until it communicated its flame to the black powder, unless the shot fell in water or the fusee was extinguished after the shot landed. As may be imagined, the percentage of fragmentations was not very high, hence the tactical requirements demanded improvement. The powder train fuse was the first endeavor. It consisted of a wooden plug with a central case of fuse powder, the outer end having a small charge of quick-burning powder. The fuse body was driven into a hole in the shot, after the inner end was cut off somewhere along its length to regulate the time to burst. Another method was to pierce the fuse body with a gimlet, and thus provide an opening for the flame to spit through into the cavity. The outer end was covered with paper for the protection of the quick-burning composition. This attempt was the beginning of the time fuse. A later development, the Borman fuse, was a flat pewter stock screwed in the shot. It had a powder ring inside the stock which burned down to the center and spit through into the cavity. By puncturing the metal covering the powder train at varying distances from the end, the time of burning could be regulated. The flame from the powder charge ignited the train where it was punctured.

Concussion fuse.

4. This type prevented extinguishing the fuse train, but if the train was too long, time was allowed for picking the shot up and dropping it over the side. The demands dictated the requirement that the fuse action should take place on the concussion resulting from the fall of the shot. Several types were used to get these results, such as using glass or plaster of Paris stocks, which would break on impact and open up a passage from the powder train into the cavity. These were not very successful, however, and were quickly followed by the percussion fuse.

Percussion fuse.

5. When priming compositions came into use, advantage was taken of the primer cap by the fuse maker to develop the forerunner of the percussion fuse. It consisted of a plunger carrying a firing point which, on impact, would move and strike the cap, and thus fire the burster charge. Owing to the fact, however, that a round shot would strike anywhere on its surface, one such as this would not always fire. To get a burst it was necessary to have three double-acting plungers with six caps, one plunger in each of the major axes. This type never came into general use, as about this time the advent of the rifled gun and the elongated projectile simplified the fuse maker's problem, as the new type of projectile always landed point first. The use of a rotating band also prevented the use of the powder gases for igniting a time train. The use of a single plunger and a primer cap was, therefore, well adapted to the improvements in ordnance. However, with the increase in the power of guns, the desire to make projectiles safe in handling and firing required other improvements. When high explosives became common for burster charges, the necessity for having a fuse which would detonate the charge and yet be safe in handling and firing became apparent and led to the detonating fuse.

Tactical requirements.

6. Besides incorporating certain safety features, the design of a fuse is regulated by the uses to which it is placed. A simple percussion fuse is required to operate on impact and fire a black powder charge. It may be either a nose fuse or a base fuse, depending on the design of the projectile. All simple percussion fuses in the United States Navy are base fuses. A time fuse must, a predetermined period after discharge, fire the burster or ejection charge, as in shrapnel, illuminating projectiles, etc. A time percussion fuse must fire after a predetermined period or else fire on impact, if not operated by the time train. A detonating fuse must detonate a high explosive charge on impact, either instantaneously or, in case of an armor-piercing projectile, a short period of time after impact in order to allow the projectile to get through the plate and explode inside a ship. All the above are types and may be each divided into classes differing in design. They are not interchangeable and consequently are assembled in advance in the projectiles and are a part of the projectiles. It is not permissible to remove fuses of any type for inspection, as this is a very dangerous operation.

Parts of a fuse. **7.** Practically all modern fuses have the following parts:

(*a*) A firing pin which strikes a primer element at the instant the fuse is intended to function. The firing pin in most fuses is attached to a movable mass and the action is controlled by the forces acting on this mass. In some types the movable mass carries the primer and the firing point is attached to the fuse proper.

(*b*) A plunger—a movable mass which is acted on by certain forces to initiate the action of the fuse.

(*c*) The primer element, usually a cap similar to those used in primers for guns, containing a small quantity of sensitive explosive, giving a good flame when fired by friction or a blow.

(*d*) A fuse stock for carrying the various parts and so made as to fit the fuse cavity in the projectile.

Forces utilized in fuse. **8.** In designing a fuse the maker has to consider the following forces, either using them to control the fuse action, or compensating for them in order to get the correct operation:

(*a*) Force of inertia of the movable parts, due to the acceleration of the projectile in the gun, usually called the "setback."

(*b*) Centrifugal force due to the rotation of the projectile.

(*c*) Retardation in flight, resulting in forward "creep" of such parts as are not affected by the retardation of the projectile.

(*d*) Retardation due to impact or the force of impact.

(*e*) Angular acceleration in the gun.

(*f*) Angular retardation on impact.

(*g*) Angular retardation in flight.

(*h*) Friction.

(*i*) Self-contained forces acting independently of outside forces, such as mechanical movements, springs, etc.

Safety features. **9.** As stated above, a fuse must be safe in handling and firing. If the fuse contains a plunger not efficiently and firmly held in place against a slight shock, the mere dropping a projectile on its point would cause it to function. A certain number of fuses and fuzes from each lot, therefore, are tested by dropping them in a projectile a predetermined height several times in order to make sure that such an accident will not occur. A fuse or fuze must be safe in loading so that the shock of ramming the projectile home will not arm the device and permit it to function on discharge of the gun. The fuse or fuze must be bore-safe; that is, not explode or arm until it has cleared the muzzle of the gun and, also, must not function prematurely, that is, before the time for which it is designed to act. Other tests are given, such as the jumbling and jolting test to insure that constant working will not release any of the parts; fragmentation tests to insure that the burster charge is properly exploded, etc.

Classification.

10. Fuses and fuzes may best be described under the heading of ignition fuses, time fuses, and detonating fuzes. Ignition fuses act by the forward motion of a plunger in the fuse body, caused by the sudden stopping or retarding of the projectile in flight. The minor caliber types, due to their small size, are usually armed by setback. The medium caliber types, on the other hand, are armed by centrifugal force. The types of ignition fuses which may be met with in service are listed above. Plate — shows the types used in service.

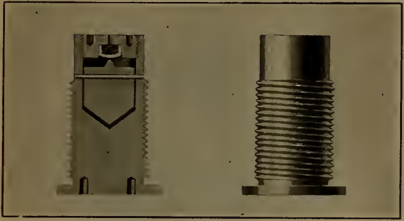


Fig. 48.—Navy Base Fuse, Minor Cal., Mk. 11, Mod. 1.

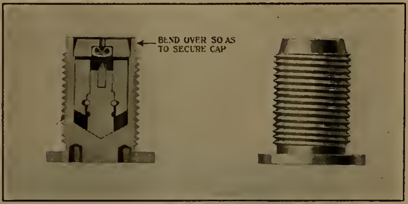


Fig. 49.—Broderick Fuse, Minor Cal., Base percussion, Mk. II, Mod. 2.

Navy base fuse.

11. The Navy base fuse, Figure 48 (Buord 53260), is the oldest type in service. It may be used in the 1-pounder common projectile. The fuse stock contains the plunger, which is held in place by a shearpin. On setback, the pin is sheared and on impact the plunger goes forward and causes the firing point to strike the primer cap, a 2½ Winchester, which spits through the channel into the cavity of the projectile. This type is satisfactory for small calibers, but does not have the necessary safety features for high powered guns.

Broderick fuse.

12. The Broderick fuse, Figure 49 (Buord 53163), consists of a fuse stock containing a plunger which is surrounded by the plunger sleeve. The sleeve is normally held in place by a split ring in such a position that the firing pin is housed. On setback, the split ring is moved down to the lower groove on the plunger by the action of the sleeve thus exposing the firing point. The combined weight of the sleeve and plunger carries the firing pin forward on impact and fires the primer cap.

Driggs fuse.

13. The Driggs fuse, Figure 50 (Buord 14464), utilizes centrifugal force to release the plunger. The stock contains a plunger, which has two channels down the sides diametrically opposite each other and to the spring. The lower end of the plunger is undercut with a collar on the end. The spring is in two parts, the lower end on each side having a half of a ring fitting into the undercut part of the plunger, thereby holding the plunger in place. When the projectile rotates, the lower ends of the spring, where they fit around the plunger, fly out and on impact permit the plunger to go forward and strike the primer cap, as in other types. The advantage of such a safety feature is that the projectile must be rotated before the fuse is armed. It should also be noted that if a projectile fall on its side, one part of the spring may disengage, but the other will hold in place more tightly.

Wilson-Chase fuse.

14. The Wilson-Chase fuse, Figure 51 (Buord 26527), consists of the fuse stock containing a plunger, with the firing pin. The firing pin is locked in the unarmed position by the centrifugal guard, consisting of two gates pressed together by a spring. As the projectile rotates, the gates, by the action of centrifugal force, swing out, freeing the plunger, which is then free to go forward on impact.

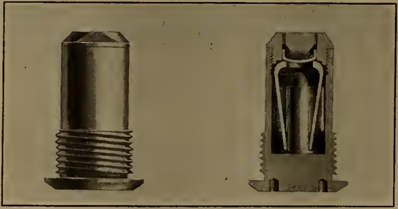


Fig. 50.—Driggs Percussion Fuse.

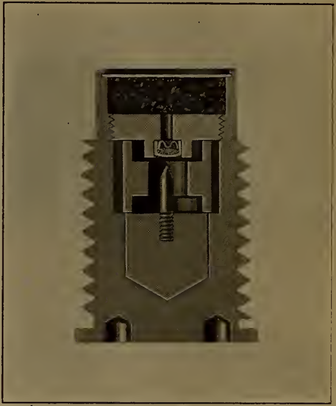


Fig. 51.—Wilson-Chase Fuse.

Semple minor caliber fuse.

15. The Semple minor caliber fuse, Figure 52 (Buord 54917), has a movable firing pin. The stock contains the plunger and plunger post, which is pinned to the plunger by a shear pin with the plunger in the forward position. The plunger is in the forward position with the firing point rotated on its hinge pin, so that it does not point toward the primer. The firing pin is attached to the plunger by the hinge pin. On setback the shear pin is sheared, the plunger rides back on the plunger post, and in so doing carries back the firing point, which straightens out as it enters the recess in the end of the plunger post and then points at the primer cap. On impact the plunger and plunger post go forward together and fire the primer. In this fuse there is, in addition to the primer cap, a magazine containing a small charge of fuse powder. While this type is not a centrifugal-acting fuse, it is to be noted in particular that the firing pin is not aligned with the primer until after the setback, and can not be so aligned until the plunger has moved relative to the plunger post.

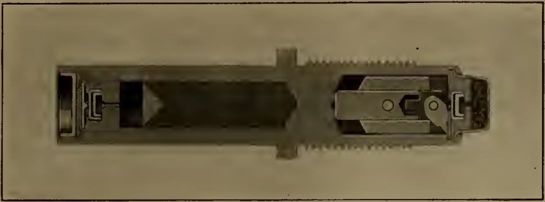


Fig. 52. Semple Minor Cal. Tracer Fuse, Mk. III.

Ansonia and Nathan fuses.

16. The Ansonia and Nathan fuses are similar to the Semple fuse but were manufactured by different companies.

Baldwin fuse.

17. The Baldwin fuse is somewhat similar to the Broderick, but differs in that a shear pin holds the plunger to the firing pin, and thus keeps the latter housed. When the plunger is forced back, a small centrifugal locking bolt flies out and hold the plunger and firing pin together, so that both go forward on impact.

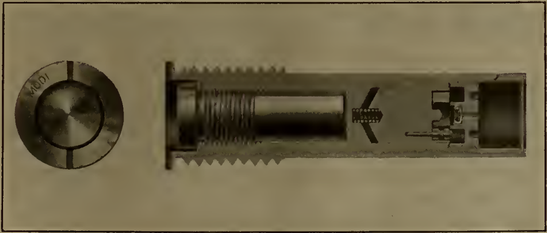


Fig. 53. Watson Medium Cal. Fuse.

Watson medium caliber fuse.

18. The Watson medium caliber fuse, Figure 53 (Buord 50210), is similar to the Wilson-Chase. It has a plunger barrier, consisting of two semicircular pieces, which open when the projectile rotates and unlock the plunger. The plunger has a small spring in the rear, which on setback is compressed, so that the turns override except about one turn in the middle. This spring prevents creep during flight, but on impact the one turn is stretched out, thus permitting the plunger to go forward.

Semple medium caliber fuse. 19. The Semple medium caliber ignition fuse, Figure 54, operates on a somewhat different principle from those previously described. The most interesting feature of it is the Semple centrifugal plunger. The plunger contains a pivoted firing pin. There are two centrifugal locking bolts, which hold the firing pin in the down or unarmed position. As the projectile rotates, the locking bolts are thrown out and the unbalanced firing pin is rotated about its axes, due to centrifugal force acting on the center of mass. The point is then aligned with the primer cap. Due to the peculiar shape of the firing pin, the effect of acceleration in the gun causes it to lag, as this force is greater than the centrifugal force and consequently during acceleration it does not align itself with the primer. When the acceleration has ceased (when the powder gases cease to act on the projectile) the centrifugal force takes charge and completes the movement of rotation of the pin.

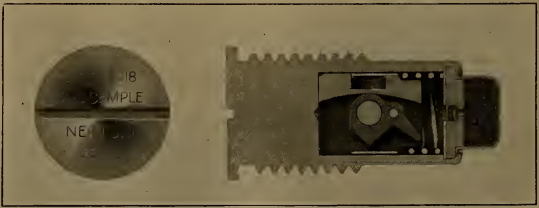


Fig. 54.—Semple Med. Cal. Ignition Fuse.

A spring forward of the plunger prevents creep during flight as, without it, the deceleration of the prejectile being greater than that of the plunger, due to air resistance, would cause a relative motion between the plunger and the stock.

Tracers. 20. Certain fuses have tracer components assembled with them, but they have no connection with the fuse action. They will be discussed under a separate heading.

Time fuses. 21. There are two types of time fuses, one having the time element only, for use against aircraft, and the other, called a combination fuse and having a time and a percussion element, for use in shrapnel on the surface. All time fuses in the Navy are powder train fuses, as no successful mechanical time fuse has been developed to date, to function properly in Navy high-powered guns. Certain mechanical time fuses will function satisfactorily at velocities lower than service. The time fuses which may be found in service are the Bethlehem 12-second combination, the Frankford Arsenal 15-second combination, and the 21-second Mark IV or Mark XI.

22. It is of the greatest importance that time fuses give uniformity of action. Even though the time of burning as set on a time train does not agree with the range table time of flight, a suitable correction may be applied to the setting after a range shot. In laying an effective barrage, however, the fuses, if set alike, should cause bursts in the same time interval in order that the range pattern may be small. The following conditions affect the uniformity of powder trains:

(*a*) Age of fuse.
(*b*) Condition of storage.
(*c*) Barometric pressure.

Effect of condition of powder train.

23. As black powder ages it becomes less sensitive, due to minor chemical changes, so that the powder train of an old fuse may be expected to burn more slowly than that of a new one. Black powder, the major component of a time-train composition, is hygroscopic. It readily absorbs moisture and this absorption will cause the train to burn slower and slower as the moisture content increases, until it fails to function when the composition becomes wet. When the composition is prepared, the work is done under standard conditions, so that the final result will give fairly uniform results. If the composition dries out, it will burn faster. If fuses in service are not subjected to fairly uniform conditions of storage, they will not function accurately on firing. All time fuses are waterproof and, in addition, are fitted with water-tight covers which are to be removed just prior to firing. If the covers become loose so that they admit moist air to the fuse, erratic fuse action may be expected.

Effect of barometric pressure.

24. The barometric pressure affects the rate of burning. This is shown by the different action of fuses fired with low angles of departure and those fired at high angles of departure. This action is very apparent in antiaircraft firing, as the fuse takes longer to act when fired at high targets than when fired at low targets. The cause is the decrease in barometric pressure. In manufacture the powder train is compressed by high pressure, so that it burns fairly slowly in a manner similar to a compressed black powder grain in a gun. Each layer is first heated by the hot gases until it ignites. With increased pressure the hot gases are kept in closer contact, hence there is less time required to bring each layer up to the ignition temperature, and the composition burns more rapidly. The gases of combustion expand more readily with decreased pressures and consequently cool more rapidly, hence transfer less heat to succeeding layers, thus causing a decreased rate of burning. The fuse action may be expected to vary somewhat on days when the barometric pressure varies, but all should function in the same way if not affected by other causes.

Effect of variation in size of projectile.

25. The action of similar time trains is also affected by the weight of the projectile and the velocity. Heavier projectiles lose velocity less rapidly than lighter ones, hence the pressure on the burning time train is greater for heavier projectiles during flight, and the train will burn faster due to the fact that the pressure remains higher. In the same way, increasing the muzzle velocity has the effect of quickening the burning of the train.

Mechanical fuse.

26. These conditions affecting the uniformity of time fuses are disadvantages, some of which could be reduced and others eliminated by the use of a mechanical time fuse operating by clockwork. However, it is most difficult to control the forces acting on the parts of a mechanical time fuse when fired in a high-powered gun. This problem, that of devising a mechanical fuse which will function properly, regardless of storage conditions, size of gun, initial velocity of rotation, or angles of elevation, is one still to be solved.

F. G. and L. G. fuses.

27. There are three types of time fuses fitted to field and landing gun ammunition and shrapnel for other purposes and one type for antiaircraft use. They are the Bethlehem 12-second combination, the Frankford Arsenal 21-second combination, the Washington Navy Yard combination Mark IX, and the Scoville time fuse, Mark XI, Mods. 2 and 3. The first two are practically obsolete and are found only in the Mark I, Mark I Mod. 1, and Mark III shrapnel, called old shrapnel. The latest shrapnel are fitted with the Frankford Arsenal, the Washington Navy Yard, or the Scoville Mark XI Mod. 1 or 4 21-second combination fuses. The Scoville Mark XI Mod. 2 and 3 time fuses are used for shrapnel, illuminating projectiles, and high explosive projectiles for use in antiaircraft work. Time fuses without percussion elements are recognized by the red tops.

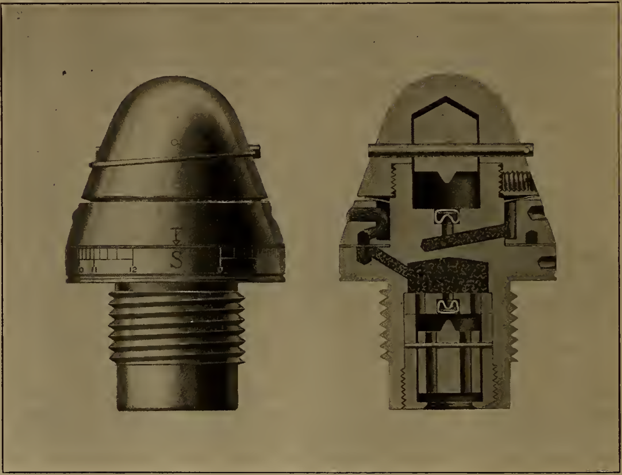


Fig. 55.—Bethlehem 12-second combination Fuse.

Bethlehem 12-second fuse.

28. The Bethlehem 12-second combination time and percussion fuse is shown in Figure 55. It has plungers and wire similar to those of the usual percussion shear-wire fuse, but the time plunger is so arranged that the shock of firing not only breaks the wire but explodes the primer cap, filling the angular cavity of the fuse with flame. This flame escapes through the vent at the same time igniting the zero end of the time train; a piece of quick match, leading from the time composition to the vent, insuring ignition. The time composition, which consists of a special mixture, is loaded in the train disk under considerable pressure. The train is of the horse-shoe type and extends through an arc of 315°. The stock is graduated in quarters up to 12 seconds. As the scale is large and distinct, settings of one-eighth second can be made without difficulty. The lock pin which is removed just before setting the fuse, furnishes an additional safety in keeping the time plunger from impacting against the primer cap if the ammunition should be accidentally dropped. A spring washer firmly holds the train disk in set position and insures good contact of the time composition with the felt cushion washer, so that burning of composition takes place only on radial cross section of composition.

29. The magazine is filled with fine-grained rifle powder. The percussion element of the fuse is similar to the usual type of wire fuse, except that the plunger is provided with longitudinal flame passages, as is also the anvil that holds the primer cap, the holes in the anvil cap being covered by a thin piece of shellacked linen.

30. The fuse is made waterproof by dipping it in a bath of shellac, a thin but complete seal being thus formed.

31. *Setting.*—The lock pin is to be used as a setting tool, either end being adapted for insertion in the setting hole of the train disk, which should be moved until the index is brought in alignment with the graduation of time desired. The initial movement in setting of the disk should be right handed, as the fuse has a right-hand thread, and reverse motion might have a tendency to unscrew the same from shrapnel head.

Frankford Arsenal 15-second fuse.

32. *Frankford Arsenal 15-second combination time and percussion fuze.*—This fuse, shown in Figure 56, is no longer being manufactured, though a number bought from the Army are in service. The action of the fuse is as follows:

(1) *As a time fuse.*—A hole is punched through the cover, the time train, and the lead cone at the point in the cover corresponding to the number of seconds desired. Just before loading, the safety pin is removed. This allows the time plunger to rest on the fuse body, where it is held by the split ring. By shock of discharge, the split-ring spring is expanded and the plunger forced to the rear, the primer in the plunger striking the point and exploding. The flame from the primer passes through four radial holes and ignites the ring of compressed powder. The only vent for these gases is the punched hole, and they ignite the time train at that point. The latter burns and ignites the powder in the tube and the magazine. The flame from the magazine charge passes through the percussion primer plug and percussion plunger and ignites the bursting charge in the shrapnel.

(2) *As a percussion fuse.*—By shock of firing the sleeve is carried to the rear. The split ring opens out and is forced back into the groove around the rear end of the plunger, where it springs into place. The plunger and sleeve are now locked together and the point exposed. On impact, both fly forward and explode the primer cap.

This fuse is set with a fuse punch, shown on Figure 59.

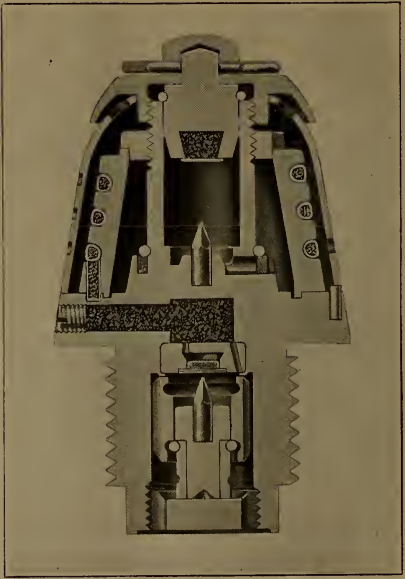


Fig. 56.—Frankford Arsenal 15-second combination Fuse.

Frankford 21-second fuse.

33. The Frankford Arsenal 21-second combination fuze, Figure 57, model 1907 M (Mark IX), is assembled as follows:

34. The body of this fuse is machined from a bronze casting. The time train rings are turned from hard-rolled rods of Tobin bronze. An annular groove in the shape of a horseshoe is milled in the lower face of each of the time-train rings. Meal powder is compressed into these grooves under a pressure of 66,000 pounds per square inch, forming a time train, the total length of which is 7 inches.

35. The time element of this fuse is composed of the following principal parts: The time or concussion plunger, the concussion resistance ring, the firing pin, the vent, leading to the upper time train, the compressed powder pellet, the upper time train, the vent, the lower time train, the compressed powder pellet, in the vent leading to powder magazine.

36. The plunger is cylindrical in shape and contains the percussion composition in a recess at its base. The weight of the plunger rests upon the concussion resistance ring, which keeps the primer from contact with the firing pin. At discharge of the gun, the resistance of the ring is overcome and the primer is exploded by contact with the firing pin.

37. As stated above, the annular grooves into which the meal powder of the time train is pressed are in the shape of a horseshoe, a solid portion being left between the ends of the groove in each ring or disk.

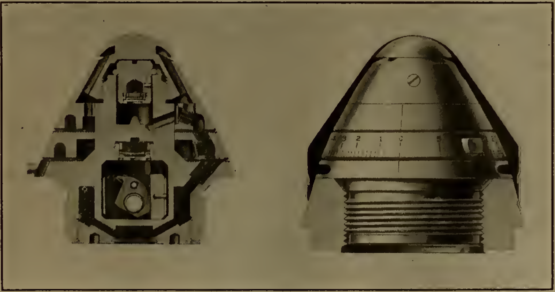


Fig. 57.—Frankford Arsenal 21-second combination Fuse.

38. The upper time train ring is prevented from rotating by pins which are halved into the fuse body and the inner circumference of the ring.

39. The vent is drilled through the walls of the concussion plunger chamber, and is exactly opposite a hole in the inner surface of the upper time train leading to the end of the train from which the direction of burning is anticlockwise.

40. The hole is drilled through the upper face of the lower time train ring to the end of the lower time train groove, from which the direction of burning is clockwise. The lower time train ring is movable and is graduated on its outer edge in a clockwise direction from 0 to 21.2, each full division corresponding to 1 second time of burning in flight. These divisions are subdivided into five equal parts corresponding to one-fifth second. A radial pin is provided in the lower ring for engagement with a notch in the fuse setter for setting the fuse. A line on the lower flange of the fuse stock is the datum line for fuse settings.

41. The vent is drilled through the flange of the fuse stock to the powder magazine and leads to the same end of the lower time train as the vent—that end from which the direction of burning is clockwise—when the fuse is at its "zero" setting.

42. The action of the fuse as a time fuse is as follows:

Assume first the "zero" setting. At discharge of the gun the time plunger arms and fires its primer. The flame from the primer passes out through the vent, igniting the pellet, the end of the upper time train, down through the vent to the end of the lower time train, and thence through the vent to the magazine, the flame from which is transmitted to the base charge in the shrapnel. It will be seen that for the "zero" setting of the fuse the origin of both upper and lower time trains are in juxtaposition. Assume any other setting, say 12 seconds: The vent has now changed its position with respect to the vent, leading to the beginning of the upper time train, and the vent leading to the powder magazine, both of which points are fixed by the angle subtended between the 0 and 12-second settings. The flame now passes out through vent and burns along the upper time train in an anticlockwise direction until the vent is reached, where it passes down to the beginning of the lower time train and burns back in a clockwise direction to the position of the vent, whence it is transmitted by the pellet of compressed powder to the powder magazine.

43. For the 21.2-second setting the vent leading to the beginning of the lower time train is opposite the end of the upper time train, and the end of the lower time train is opposite the vent leading to the powder magazine. It will now be seen that to reach the magazine and burst the shrapnel, the entire length of time train in both rings must be burned.

44. As already stated, the annular grooves in the lower face of each ring for the powder trains do not form complete circles, a solid portion being left between the ends of the grooves in each. This solid portion is utilized to obtain a setting at which the fuse can not be exploded by the time train and is known as the "safety point."

45. This point is marked by a line on the outer edge of the movable time train, surmounted by an S, and is located about halfway between the zero mark and the 21.2-second graduation. When this point is brought opposite the line on the lower flange of the fuse body the vent is covered by the solid metal between the ends of the upper train, and the vent, leading to the powder magazine, is covered by the solid metal between the ends of the lower or movable time train. At the safety setting it will be seen that the upper train may burn entirely out in case of accidental firing of the time plunger, or in case it may be desired to burst the sharpnel by impact or percussion, without the flame being able to reach the magazine.

46. The cloth washers are glued to the upper face of the graduated time-train ring and to the upper face of the flange on the fuse stock. These surfaces are corrugated, as shown, to make the washers adhere more strongly. The function of the washers is to make a gas check and prevent premature action of the fuses.

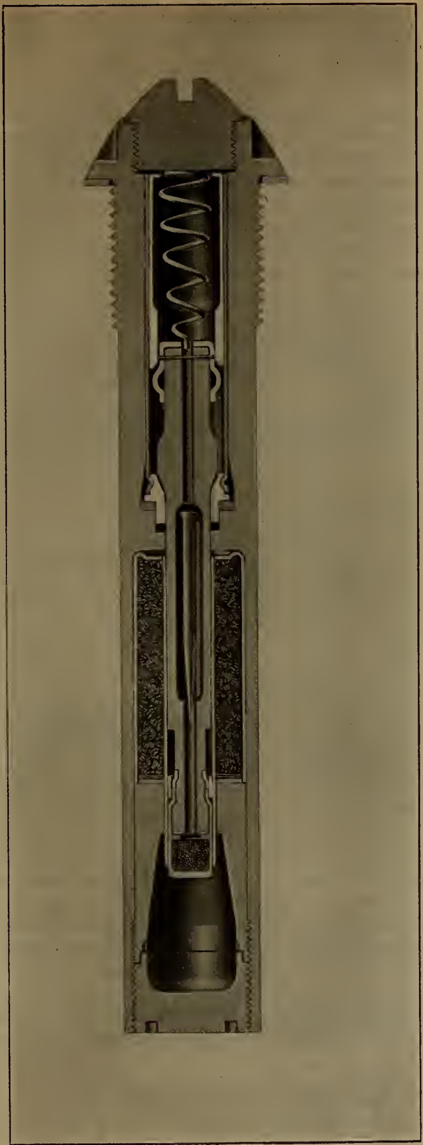


Fig. 58.—Detonating Fuse Mk. VIII.

47. The compressed pellet in the vent leading from the outside to the beginning of the lower time train is to release the pressure of the gases due to the burning train. The gases from both time trains escape into the outer air through the annular spaces shown in the illustration and the vents in the closing cap.

48. The percussion element of this fuse consists of a percussion plunger, and an ordinary percussion primer.

49. The system of vents through the walls of the fuse conduct the flame from the percussion primer to the magazine.

50. The bottom closing screw closes the percussion plunger recess and keeps the powder in the magazine. The muslin washer is coated with shellac and held in place by the brass washer, over the outer edge of which a projecting lip is crimped.

51. These fuses are issued assembled in shrapnel and set at safety. For transportation in limbers and caissons the fuse should always be set at the safety point, if cover has been removed and original setting changed.

52. The fuse is provided with a water proof hood of thin brass, hermetically sealed. The hood should be stripped off before an attempt is made to set the fuse. The powder time trains of these fuses are affected by prolonged exposure to air and the waterproof hood should only be removed immediately before firing. Every precaution should be taken not to allow water to get into the ventilating holes as this will render the fuses ineffective. Particular care in this respect is necessary when serving the guns in wet weather.

53. The action of the Mark XI fuse of the Washington Navy Yard manufacture is the same as above.

Scoville fuses. **54.** The Scoville Mark XI Mod. 1 and 4 are similar to the Mark IX fuse. The Mark XI Mod. 2 and 3, however, do not have a percussion element.

Detonating element. **55.** The time fuse in its capacity of ignition fuse cannot detonate a burster charge of high explosive. To get the desired results a detonating element (Semple anti-aircraft fuse Mark VIII) is introduced between the fuse and the charge.

Fuse setters. **56.** Ammunition in which time fuses are used may be roughly divided into that used, first, for surface work, either afloat or ashore, such as shrapnel against bodies of troops, earthworks, etc., or against small, light, unarmored craft; and, second, for antiaircraft work in repelling aircraft attacks. The principal use of a time fuse is in laying a barrage in the air or in producing zone fire. Tactical requirements demand that a barrage be mobile, in that it may be quickly shifted as occasion demands. To produce the best results time fuses must be quickly and accurately set, and to obtain this result fuse setters are provided. Before the advent of fuse setters, fuse punches and wrenches were used for the older types.

Fuse punch. **57.** The 15-second fuse punch, is a device for setting the time fuse Mark VII (Frankford Arsenal 15-second combination fuse, model of 1894) to burst at various times of flight.

(*a*) The fuse punch consists of the following parts: Two grips, a punch, lock screw, and lock-screw spring. The grips are held together by a hinge pin and nut. One grip has near the hinge a bevel which fits over the fuse, while at a similar location on the other grip is located the punch. On the inside surface of the grips, near their ends, are serrations. The hinge end is provided with an eye. The punch is a small hardened piece, provided with a sharp point for piercing the cover, time train and time-train cone of the fuse. This punch is held in place by the adjustable lock screw, which after being set is held from turning by the lock-screw spring.

(*b*) Use of the fuse punch: Remove the tin-foil protecting cap from the fuse and place the punch at the division of the time train corresponding to the time of flight desired and squeeze the grips smartly together, so as to cut completely through the cover, time train and cone perpendicular to the axis of the cone. It is absolutely necessary in punching or setting the 15-second fuse to make sure that the time-train cone is cut through. For this reason the punch should always project from the inner surface of the grip at least 0.45 inch, and should not be adjusted to any other length, as it is probable that with a shorter length the punch projection will not cut through into the flame cavity of the fuse. A drill of small diameter or a wire nail, or anything of similar size and strength, may be used for setting the fuses, provided its point penetrates the fuse approximately one-half inch so as to enter the

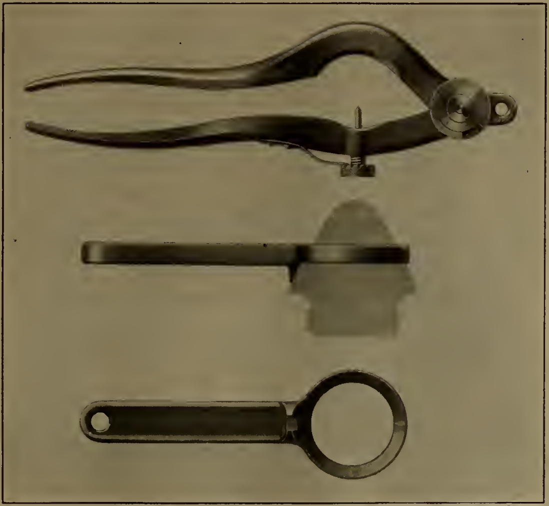


Fig. 59.—15-Sec. F. A. C. Fuse Punch and 21-Sec. F. A. C. Fuse Wrench.

flame cavity. Then remove the safety pin in the fuse and the fuse is ready for firing.

(*c*) If the fuse is to be used for percussion action only, the tin-foil cover need not be removed or the safety pin withdrawn, as the fuse will operate on impact without the removal of the safety pin.

Fuze wrench.

58. The 21-second fuse wrench, is a tool for setting the Frankford Arsenal 21-second combination fuse, model of 1907, the type which is provided with a slot instead of a fixed stop pin in the body of the fuse. It is a one-piece tool provided with a handle, having a loop or ring which fits over the fuse, and two lugs, located on the underside of the handle, that span the rotating pin on the time-train ring of the fuse. Care should be taken not to deform these projecting lugs.

(*a*) To use the fuse wrench, place the loop end over the fuse so that the lugs will straddle the rotating pin. The graduations for the time of flight given on the fuse time-train ring must be used for setting the fuse. The fuse wrench can be rotated in either direction without reversing the tool; this permits a correction to be made in either direction when trying to set the desired time of flight graduation on the time-train ring to the index line on the fuse body. This fuse wrench should not be used for setting the 21-second Frankford Arsenal fuse, model 1097-M (2-lug type), except in case the regular fuse setter is not available, as the operating is too slow. The fuse wrench may be used for setting 21-second F. A. C. fuses when fitted to shrapnel for broadside guns for which no fuse setter is provided.

THE HAND FUSE SETTER FOR 21-SECOND F. A. C. FUSES.

Hand setter.

59. The hand fuse setter, Mark I, Figure 60, is a device for setting the 21-second F. A. C. fuses, model 1907–M (Mark IX or Mark XI, or Scoville Mark XI–1), to burst at the point desired for any given range. It consists of the following principal parts: Base, case, range, ring carrier, range ring, and corrector scale. The base carries the stop pin against which the fixed stop pin on the fuse body takes when the time-train ring is rotated clockwise to the proper setting. The case is screwed in the base and carries the corrector scale and wing nut for clamping the range-ring carrier in the desired position. The range-ring carrier has secured to it by four screws the reversible range ring.

(*a*) The range ring has marked on one face range graduations in yards for a muzzle velocity of 1,650 foot-seconds, and on the reverse face range graduations in yards for a muzzle velocity of 1,150 foot-seconds. The face with the 1,650 foot-seconds graduation is used for setting fuses to be fired from the 3-inch landing guns Mark IV and VII, while the face with the 1,150 foot-seconds is used with the 3-inch field gun Mark I Mod. 1. The range ring is located on the carrier by a dowel pin.

(*b*) The corrector scale is divided into six main divisions which are in turn subdivided into 10 smaller divisions, giving a total of 60 divisions of 1 mil each. The object in having the corrector scale is to enable the time or position of burst to be varied without changing the designated range. The Field Artillery unit for such adjustments is the mil, and is equal to 1/1600 of a quadrant, angular measure. This is the graduation of the battery commander's telescope and the panoramic sight fitted to our Mark VII landing guns, and is equivalent to approximately 1/1000 of the range. Hence, the value of the mil, in yards, changes with the range. The ideal point of burst to obtain the maximum destructive effect of a shower of shrapnel balls is generally taken to be at a height of 3 mils, or 3/1000 of the range. To secure this point of burst, being given the range, turn the fuze setter handle until the required range is in line with the index, which has been set on the "30" mark on the corrector scale. A shrapnel fired after time setting with the fuze setter thus adjusted should burst 3 mils high. If, owing to the terrain or to variation in the rate of burning the fuze train, it is desired to change this point of burst, the spotter simply orders the position of the corrector scale index changed, increasing the reading for a higher burst, or one nearer the gun, and decreasing it for a lower burst or one nearer the target, and the range on the range ring is reset opposite the corrector scale index. The setter is then ready for setting the fuse for the next shot.

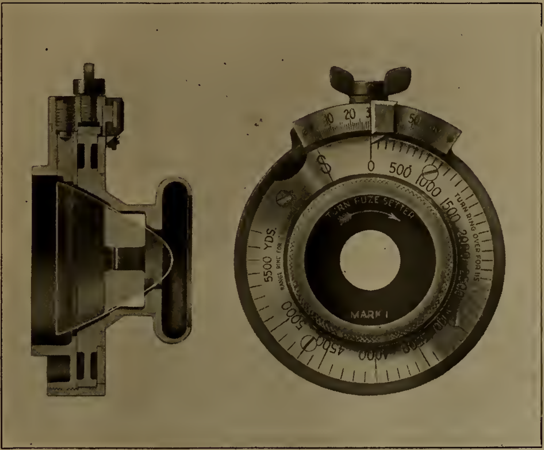


Fig. 60.—3″ Hand Fuse Setter.

(*c*) To explode the shrapnel on impact, or for safe transportation, the S on the range ring (of the fuse setter) should be opposite the 30 mark on the corrector scale. Great care should be taken that this setting is accurate.

(*d*) To use the hand setter, set the range and corrector scales at the range and correction ordered, and clamp; remove the weatherproof cover on the fuse by ripping off the soldering strip; place the fuse setter over the point of the shrapnel and turn the handle of the fuse setter in a clockwise direction until the rotating pin of the fuse engages in the notch cut in the range ring carriers. Then press the fuse setter firmly down and continue to turn in a clockwise direction until the fuse stop in the fuse setter base engages with the fixed stop pin in the fuse body and prevents further rotation. Special care must be taken to rotate the fuse setter in a clockwise direction.

60. As a drill for practice with the fuse setter, set range ring and corrector scale to reading given in the table below. Set the fuse with the fuse setter and compare the setting of the fuse with the time given below. Use a fuse on a shrapnel in making the test.

Range in yards, hand fuse setter.	Corrector scale.	Time in seconds on fuse.	
		1,150 f. s.	1,650 f. s.
0	30.0	0.00	0.00
2,000	3.9	7.81	6.66
3,750	45.0	11.86	10.23
4,500	30.0	15.76	14.30

61. Preliminary drill in setting fuses with the fuse setter (and fuse wrench) is essential to efficient serving of the gun in target practice or in action. It is desirable that this drill should be held with service ammunition so that the crew may gain the necessary experience in handling this ammunition. As the fuses are affected by prolonged contact with the air, however, the fuse covers should be removed from only as many rounds of ammunition as are absolutely necessary for the purpose of conducting fuse setting drills.

62. The hand fuse setter should be disassembled from time to time and thoroughly cleaned and oiled. To disassemble, remove the corrector scale, unscrew the clamp screw, remove the clamp shoe, remove plug, unscrew the base from the case, and withdraw the range ring carrier with range ring. Clean thoroughly, oil, and assemble in reverse order. To turn over the range ring, it is necessary to remove the four range-ring screws. Do not remove the small dowel pin. Do not remove the sliding index from the corrector scale, as small parts may be lost, and difficulty will be experienced in assembling. Care should be taken in assembling to see that the index lines on the under side of the casing and base are coincident, as otherwise an error will be introduced in the setting of the fuze. When not in use, the fuse setter must be kept in the leather box provided for this purpose.

63. With the new requirements for rapid fuse setting for antiaircraft work, a new type is required, as the Mark I is too slow. In using this type it is necessary to have the fuses set ahead of time by zones. Improvements on this type are now in the experimental stage which, when perfected, will permit adjustments to be made for varying angles of elevation, different scales being used for different guns.

64. For special conditions in firing illuminating projectiles, see Ordnance Pamphlet 389.

Detonating fuse.

65. The details of detonating fuses as used in the service are not published as they are highly confidential. In order that the difference between an ignition fuse and a detonating fuse may be known, Figure 58 is included in this pamphlet showing how a detonating fuse may be made to function. The plunger, the primer, and the magazine are similar to the Semple base ignition fuse. The fulminate detonator is held in the central or run tube by the barrier gates. The chamber is empty and designed to hold the force of the explosion of the fulminate should it go off prematurely. The booster (see ch. 9) is contained in the chamber, and consists of picric acid, tetryl or recrystallized T.N.T.

66. When the gun is fired the plunger acts as in an ignition fuse. At the same time, due to rotation of the projectile, the barrier gates are thrown out against the springs by the action of centrifugal force and as the projectile is retarded the fulminate detonator creeps forward in the run tube until it is adjacent to the booster. On impact the primer cap is fired and ignites the magazine, which transmits flame to the fulminate exploding it, thus detonating the booster, which in turn detonates the burster charge of the projectile.

67. A special type of fuse is used in flat-nose or cup-nose projectiles. It is the Mark VII, nose detonating fuse (Fig. 58). This fuse was adapted from a Russian fuse.

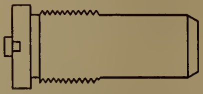
68. The fulminate detonator is held in the safety chamber. On setback the sleeve rides over the stirrup, so that on impact the detonator rod may go forward and cause the detonator to strike against the firing point, which is held firmly in place by a bridge, thus causing the fulminate to explode near the booster.

Tracers.

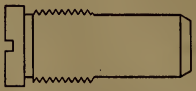
69. In order that a projectile may be followed in flight tracers are provided. There are two kinds, the day tracers, as used in the 1-pounder automatic gun shown in Plate 8, chapter 11, and the night tracer shown on Plate 12. Certain fuses have the tracers incorporated in the same fuse stock. Others are provided especially for target practice or for projectiles which use nose fuses. The general principles of all are the same. The larger number of tracers are fired by the action of the powder gases on a plunger. A cap is fired igniting the mixture. One type of tracer fuse is built on the principle of firing the primer cap by setback. Plate 16 shows the outline and marks of separate tracers issued to service. The details of the burning composition are not published.

PLATE XVI.

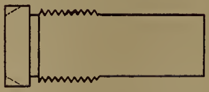
Outline of Tracers.



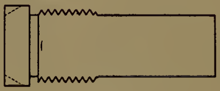
TARGET TRACER, MARK I.



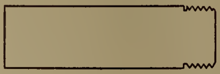
TARGET TRACER, MARK II.



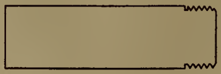
TARGET TRACER, MARK II, MOD. 1.



TARGET TRACER, MARK II, MOD. 2.



TARGET TRACER, MARK III.



TARGET TRACER, MARK III, MOD. 1.

Chapter XIII.

PRIMERS.

Function of primer.

1. A primer is a device for initiating the explosion of the propelling charge in the chamber of the gun by means of a flame. When the propellant is ignited directly from the primer action, the primer is called a "case" primer, as, in the ammunition in which this action occurs, the charge is always contained in a cartridge case. When the primer sets off an intermediate ignition charge which ignites the main propelling charge, it is called a "lock" primer, as it is always used in a firing lock attached to the gun. It was pointed out in the description of smokeless powder that each grain presents a hard, smooth surface without interstices, and that a flame causes a burning along the surface alone. It is necessary to have the flame endure for an appreciable time in order to raise the temperature of the surface of the grain to the ignition point. This means that the whole charge must be bathed in flame for an appreciable length of time before a sufficient chemical reaction has taken place to support the combustion without the aid of an outside agent. Smokeless powder is difficult to ignite unless the igniting flame is applied for an appreciable time, and this flame must be very hot. The heat conductivity of smokeless powder is such that a short or local application of heat, such as would happen if a spark were to touch it, would be dissipated without effect.

Ignition.

2. It is necessary to provide some agent which will supply the required hot flame and maintain it for a long enough period of time to permit the combustion of the charge to keep the action going. In the search for a material, black powder presented itself as the one most suited for this purpose. It is ignited by heat and each grain has an interstitial formation which permits the flame to propagate more rapidly than in smokeless powder and, although its ignition point is higher than that of smokeless powder, its conductivity is considerably less and it ignites more readily. For this reason all smokeless powder charges are ignited by a black powder charge, either separately provided as the ignition charge, or as a part of the primer. As black powder is readily ignited either by heat, electric spark, friction, shock or by chemical reagents, it is then a simple matter to provide for igniting it. This is the function of the primer. The usual practice is to have the primer fire by percussion by means of a percussion cap, or by electricity by means of a heated wire. How these are accomplished will be described later. The train of action is, first, the firing of the primer cap or the heating of the wire, which is accomplished by closing the firing key; next, the ignition of a small primer charge of fine black powder, and then the ignition of the black powder ignition charge. The flame from the ignition charge causes a sudden elevation in the temperatures of a part of the propelling charge so that decomposition starts and combustion proceeds with the evolution of gases and heat.

Types of primers.

3. The design of a primer proper is not affected by the amount of ignition powder required, but is affected by the method of using she ignition charge. Thus for all bag guns the same design of primer fulfills the needs. For case ammunition, however, the ignition charge is combined with the primer and as the ignition charge varies with the powder charges, the design varies. The primer for a 1-pounder does not require as much black powder as one for a 4-inch gun. The case primer is therefore divided into different types, according to its uses. The case percussion primer is used in 1, 3, and 6 pounders and 3″/23 guns. This primer has insufficient ignition for a 3″/50 gun, so more black powder was added as an ignition charge, and the case ignition percussion primer was evolved. A modification of this primer, so that it may function either by percussion or electricity and by the addition of still more ignition powder, makes it adaptable for all case guns above the 3″/50. All bag guns use the same type, the lock primer.

Manufacture of primers.

4. Primers are manufactured out of special primer brass, rolled out in solid rods. By means of automatic machines and turret lathes, these brass rods are machined to uniform dimensions for the primer stocks. The smaller parts are likewise made by automatic machines. The percussion element consists of a copper cap containing a special cap mixture of the following composition: 35 per cent fulminate of mercury, 35 per cent chlorate of potassium, and 30 per cent sulphide of antimony. This mixture is sensitive to shock and when exploded gives a sudden blow and an intense flame of very short duration, which, acting on a small charge of black powder, starts the ignition. Percussion fire only is provided for 3″/50 guns and below, and combination fire is provided for all other guns. This division is made on account of the requirements for assembly, the use of guns, rapidity of loading, and necessity of salvo firing. Percussion fire is required for all large guns in case of a failure to fire electrically.

Designation of primers.

5. The following table shows the primers in use in the service:

No.	Type.	Mark.	Use.
1	Case percussion	X and mods	1, 3, 6 pounder 3″/23.
2	Case percussion ignition	XIV	3″/50.
3	Combination ignition	XIII	4″/50 and up.
4	Lock (combination)	XV, XV-1	All bag guns.
5	Case percussion	XVII	Davis gun only.
6	Lock (electric drill)	XVI	For test only.

Drill primers.

6. There are certain other types of primers still to be encountered in service, not listed above, which have been designated as drill primers. They are simple electric, simple percussion, or especially designed for drill purposes. It is to be noted that primers issued for drill purposes are for use in testing firing circuits. The general rule is to allow 100 per bag gun per year. In addition 10 service primers are allowed

PLATE XVII.

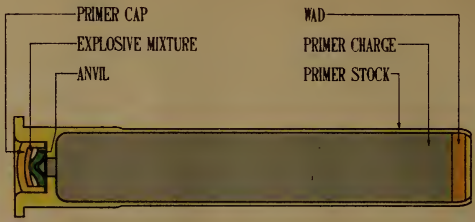


FIG.1. CASE PERCUSSION PRIMER, MARK X, MOD. 4.

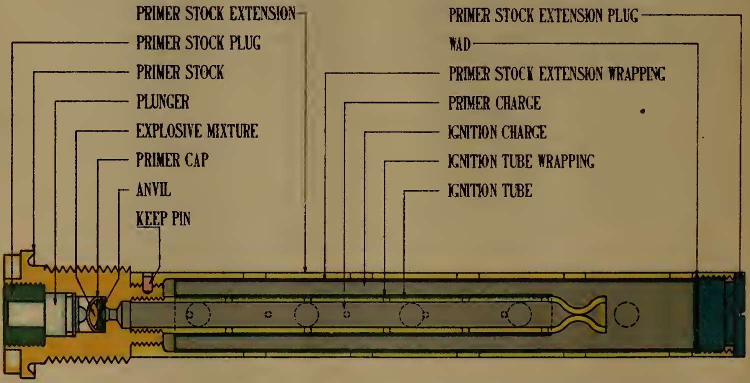


FIG.2. CASE PERCUSSION IGNITION PRIMER, MARK XIV.

Case Percussion Primers.

per year for the same purpose. Drill primers should not be used for firing either target practice or full charges, except in an emergency.

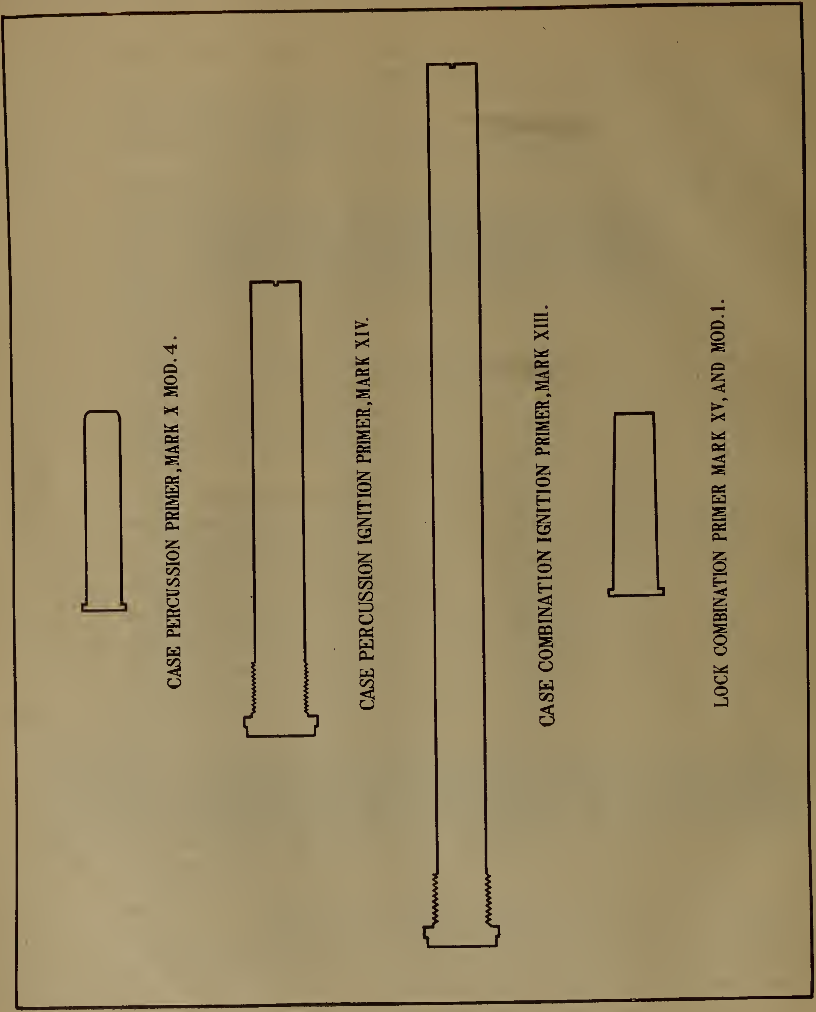
7. The Mark X Mod. 4 primer is shown on Plates 17 and 18—(Buord drawing 54228). The explosive mixture in the primer cap is shown resting against the anvil. The flame from the exploded cap passes through the case orifice and ignites the black powder of the main primer charge when the firing pin drives it in.

8. The Mark XIV primer is shown on Plates 17 and 18—(Buord drawing 44527). It differs from the previous type in that the ignition charge is contained in the primer stock extension. The primer cap is struck by the plunger and driven against the anvil, discharging the flame from the exploded mixture into the ignition tube in which is placed 3½ grains of loose, fine black powder. The ignition tube extends down into the primer stock extension and is surrounded by the ignition charge of 110 grains of fine black powder. To permit a ready access to the ignition charge, the ignition tube has a number of perforations which are covered by paper held in place by shellac, and which are blown out by the charge in the ignition tube, setting off the ignition charge. The primer stock extension is similarly perforated and has its inner surface covered with two thicknesses of paper held in place by shellac. The ignition charge is thus placed in the center of the propelling charge and ignites the powder grains by the flame which emerges from the perforations of the primer stock extension. This primer is for percussion fire only.

9. Plate 56 (appended)—(Buord drawing 36392) shows the assembly of a Mark XIII case combination ignition primer. It differs from the case percussion ignition primer in that it has the electric firing element added and it contains a larger ignition charge. The percussion element and the assembly of the ignition tube and ignition charge are the same as with the Mark XIV, except the 110 grains is increased to 265 grains of fine black powder. The main difference comes in the electric firing device. The percussion plunger is insulated from the stock, as is the plunger cup. A platinum wire bridge is soldered in place, connecting the plunger cup and the primer stock, so that this part of the circuit is made through the bridge from the firing point, touching on the plunger, to the primer stock, cartridge case, and gun. A small wisp of guncotton is wrapped on the platinum wire and the cup is filled with fine black powder and pyrocellulose. For percussion fire the action is the same as for the primer described above. For electric fire, when the circuit is closed, the resistance heats the bridge, fires the wisp of guncotton, and burns the small charge around it, ejecting flame into the ignition tube and firing the primer.

10. Plate 56 (appended)—(Buord drawing 44450) shows a lock combination primer Mark XV. It is a combination primer and in all respects is the same as the previously described primer as far as the percussion and electric elements are concerned. The primer charge consists of only 30 grains of black powder. The end is sealed by a metallic seal slotted to permit the discharge of the hot gases and flame through the vent and against the ignition charge of the powder bag.

11. The Mark XVII primer is similar to the Mark X, except as to size; and the Mark XVI is similar to the Mark XV, except that it is not intended for service use and should not be used in firing a full service charge.



CASE PERCUSSION PRIMER, MARK X MOD. 4.

CASE PERCUSSION IGNITION PRIMER, MARK XIV.

CASE COMBINATION IGNITION PRIMER, MARK XIII.

LOCK COMBINATION PRIMER MARK XV, AND MOD. 1.

Outline of Primers.

Chapter XIV.

ASSEMBLED CHARGES.

Issues to vessels.

1. Ammunition as issued to ships is prepared in all respects for use and does not require any work to be performed on it aboard ship, except for setting of time fuses and assembling of saluting charges. The Bureau of Ordnance obtains all the component parts from Government plants or from private manufacturers, except wads, distance pieces, tags, paints, luting, and similar materials which are obtained by ammunition depots on requisition and prepared for use. Ammunition details, powder, projectiles, fuses, tracers, explosives, cartridge cases, tanks, and boxes, are distributed by the Bureau of Ordnance among the ammunition depots in accordance with plans for the ultimate distribution of assembled charges to ships. Orders for the assembly and issue of ammunition originate in the Bureau of Ordnance, based on the requirements for service and target practice uses. A careful check on each ship's ammunition is made from the various reports received, in accordance with Navy Regulations, and from a consideration of her allowance list and target practice requirements, as set forth in the orders for gunnery exercises. Ships desiring additional ammunition or desiring to turn in ammunition, except for temporary storage, shall refer the matter to the Bureau of Ordnance. Vessels or stations desiring ammunition obtain it from the bureau by a request in letter form. Ammunition depots are authorized to issue only certain materials, such as small arms, etc., to vessels direct, and then only to fill allowances.

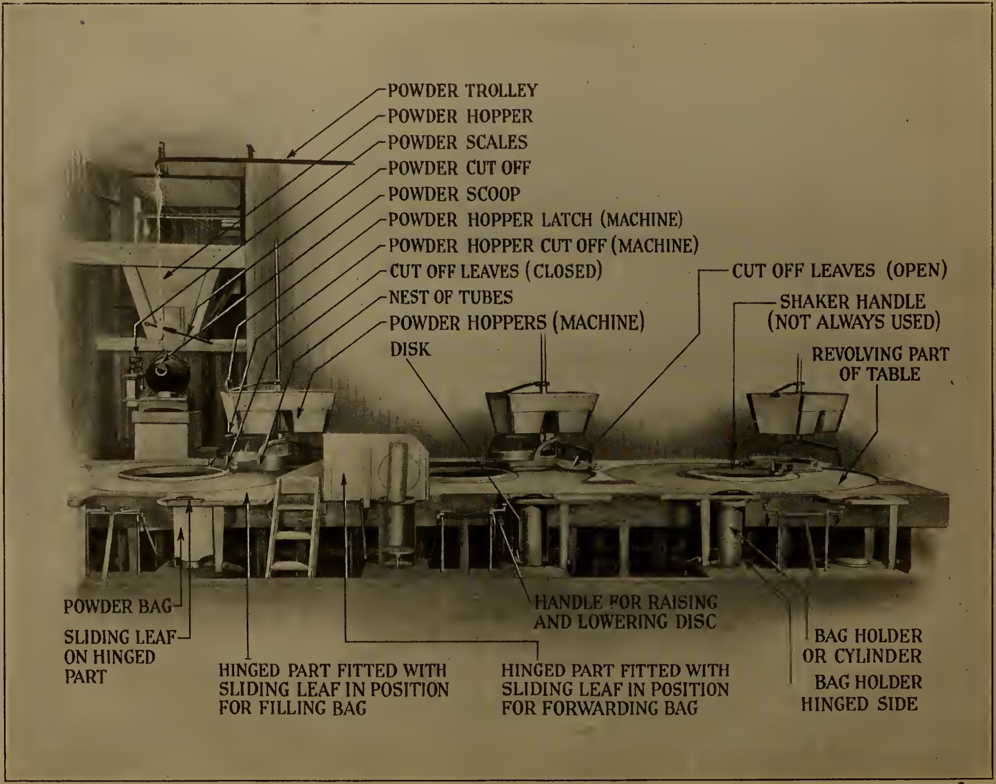
Ammunition orders.

2. Ammunition depots report the amounts of all details on hand to the bureau yearly, and thereafter whenever a change occurs, so that when it becomes necessary to provide a ship with ammunition, exact specifications of the order may be supplied the depot from the latest information on hand. In preparing an order in the bureau, the index of the powder is selected, the projectile, fuse, primer, and projectile filler are specified, having due consideration for the armament of the ship and the use to be made of the ammunition. A very careful check is made of all details of the order by several officers and clerks, in order to prevent errors creeping in. This system requires a centralized organization, due to the fact that the latest information regarding batteries, requirements, proposed changes, contemplated movements of ships, and materials available at the various depots is better known in the bureau than elsewhere.

Handling orders.

3. When an order is received at a depot, it is checked by the inspector, the ammunition officer, and the ammunition clerk with the records at the depot to insure that the weight of charge agrees with those previously assigned and the ammunition is suitable for the battery of the ship for which ordered. To allow for

PLATE XIX.


POWDER TROLLEY
POWDER HOPPER
POWDER SCALES
POWDER CUT OFF
POWDER SCOOP
POWDER HOPPER LATCH (MACHINE)
POWDER HOPPER CUT OFF (MACHINE)
CUT OFF LEAVES (CLOSED)
NEST OF TUBES
POWDER HOPPERS (MACHINE)
DISK
CUT OFF LEAVES (OPEN)
SHAKER HANDLE (NOT ALWAYS USED)
REVOLVING PART OF TABLE
POWDER BAG
SLIDING LEAF ON HINGED PART
HINGED PART FITTED WITH SLIDING LEAF IN POSITION FOR FILLING BAG
HINGED PART FITTED WITH SLIDING LEAF IN POSITION FOR FORWARDING BAG
HANDLE FOR RAISING AND LOWERING DISC
BAG HOLDER OR CYLINDER
BAG HOLDER HINGED SIDE

Stacking machine N. A. D. St. Juliens Creek.

this check, each ammunition depot is kept informed of all changes in assignments of powders and of all ship's allowances. The ammunition order is then made out as a job order at the depot, this order specifying in detail the work to be performed. The details, which are stowed in separate magazines and storehouses, are then provided and arranged in the filling house to be used. All preliminary work which can possibly be done on the details is performed before the actual assembly, such as the printing of tags, stenciling of boxes, inspection of cases and containers, cleaning, gauging of projectiles, etc.

Loading projectiles.

4. Before loading projectiles, they are cleaned, inspected, gauged, and the interior of cavity given a coat of cebaline or similar paint. At the same time the fuses are inspected and gauged. The data required in chapter 18 is then stamped on the rotating band or base of the projectile. To load with black powder the projectile is placed nose down in a holder, a copper funnel inserted in the base, and the required amount of black powder is poured in. The powder is settled by a special settling table, which gives a bumping motion to the projectile carrier. A wooden former, the shape of the fuse, is then forced gently down, making a cavity the exact size of the fuse, the funnel having been removed. The fuse threads are then cleaned with a small brush dipped in alcohol, and the fuse, on the threads of which a luting has been applied, is then entered and screwed home. The final setting home of the fuse is done in a room barricaded from the other operations by a concrete wall. A special fuse wrench, or fusing machine, is used for this purpose.

5. Unfusing of projectiles is governed by special instructions.

Mixed filler.

6. Certain projectiles are loaded with a mixed filler. This is black powder and granular T. N. T., or black powder and explosive "D." Black powder alone is insufficient for giving a good fragmentation to the present tough common projectiles. If a high explosive is used, a detonating fuze will be required and the fragmentation will be such that the pieces are too small to do any real damage. A happy mean is obtained by using a mixed filler with an ignition fuse. One half by weight of T. N. T. or "D" is placed in the cavity first, and the projectile bumped, and an equal amount of black powder is then added. The other operations are the same as when loading with black powder alone.

Compressed charges.

9. Two other methods of loading explosive charges in projectiles are used, that of compressing the charge or of casting the charge. Certain high explosive projectiles are assembled with compressed or cast T. N. T. charges. In the latter case the T. N. T. is melted and poured in, and when cool a fuse cavity is drilled out. Armor-piercing projectiles are loaded with explosive "D," under high pressure, in special power presses. The fuze cavity is made by a former fitted to the rammer head. Shrapnel and illuminating projectile loading are treated in chapter 10.

Case ammunition.

8. In assembling case ammunition the first step, after the gauging and inspection have shown that the cases are satisfactory, is the priming. For ammunition from 1-pounder to 3″/23, the case percussion primer is used. This is of the so-called drive type and is assembled in a press which forces the primer into the orifice in the cartridge-case head. This operation is very simply performed by a small press, usually operated by foot; 3''/50 cartridge cases take the case percussion ignition primer, which is screwed into place. This operation is done in a machine power or hand operated. Cartridge cases above the 3''/50 take the case combination ignition primer, which is also a screw primer, and which is assembled in the same way as the percussion ignition primer. Before assembling primers, a number from the lot to be used are tested in a primer-testing machine, to make certain that they will function when struck a blow of predetermined force. In this way doubtful lots, or any found to have deteriorated in storage, are eliminated. This method does not, however, test each individual primer for the percussion test, as such a precedure is not practicable. Consequently an occasional primer may be encountered which fails later, but considering the number used yearly the percentage of failures is negligible. The powder charge is weighed out in carefully adjusted scales, which are checked hourly with check weights frequently tested by the Bureau of Standards, and dumped into the individual cases. A wad is then entered and this is followed by a distance piece. The distance pieces are specially cut for each weight of charge, so that the entire space in the case will be taken up and the powder will not get away from the primer. These are not used, however, for antiaircraft ammunition, due to the danger from jams. The cases are then removed to the projectile-loading machine, where a projectile, after it has been loaded and painted, is entered in each case and then forced into place in a press. The cartridges are then tanked or boxed and are then ready for shipment. The powder index number is stenciled on the cartridge cases before loading and a tag is put in with the charge giving the necessary information regarding the loading.

Bag charges. **9.** In preparing bags for charges, the following materials are used, silk cartridge-bag cloth, silk lacing, silk thread, and black powder. The cartridge-bag cloth is pure silk without the admixture of any other material whatever, except the sizing for the yarn. Only sufficient sizing as is absolutely necessary is used. It is sodium or aluminum silicate or sulphate. The cloth is plain single or double basket weave and must pass certain required trade tests. Two grades are used, the heavy for the body of the bags and the light for the ignition ends. The silk lacing is made of pure spun silk, woven, and must not fray or ravel. Standard silk thread is used in stitching the bags together.

Ignition ends. **10.** The ignition ends are made up first, and sewed to the bags afterwards. In preparing ignition ends, circular pieces are cut of the light-weight silk, some plain color and some dyed red. A plain color and a red are then taken and stitched together around the periphery, except for a small space for filling. The remaining operations are done in a special so-called "quilting house," as there is some risk attendant on the operation. The bag formed by the ignition end is filled with the proper amount of black powder and the opening stitched together. The pad is then placed under a special sewing machine, the charge smoothed out and evenly disposed before the quilting operation is started. By using a broze needle this operation is made safer. The quilting holds the powder in place uniformly distributed. The ignition ends are then sewed into the bags, which have been cut and sewed up, and the whole bag is stowed in air-tight containers for transportation and storage.

Assembly of bags.

11. Bag charges are either stacked or loose. It will be noted that the sizes of charges are fixed as to length. It is important, for the purpose of obtaining uniform velocities, that the charge should always be disposed in the chamber the same way. The general rule is that the total length of the sections, placed end to end, will be about 4 inches less than the length of the powder chamber. This rule does not hold in all cases, due to the length of the powder tanks. In assembling loose charges, the powder, after being weighed out and checked, is dumped in its bag; the bag is then rolled and laced tightly in order to make a compact package. A tag is laced in the packet of the bag giving the details of the loading. The sections, after gauging for size, are then put in tanks on which a clean piece of wrapping paper has first been placed.

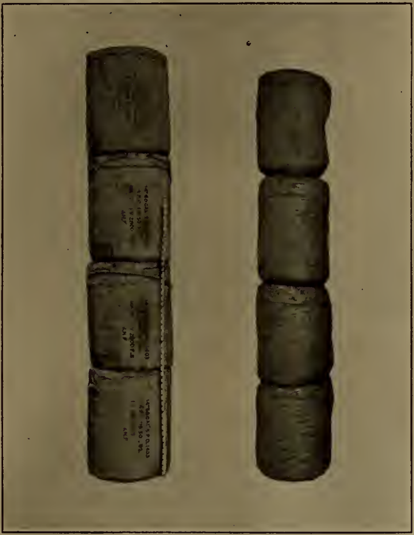


Fig. 61.—Loose and Stacked Section of 14″ Charge.

Stacked charges.

12. With large charges, loose packing has been replaced by stacked charges. Stacking places the powder grains on end in layers in such a way that a tight, compact charge is obtained. The result makes it easier for the loading crews, a smaller charge for handling, and a longer life to the bag, as there is less chance for the sharp edges of the grains to cut the cloth, as the charges chafe in the tanks, due to the motion of the ship. Stacking is done in a special machine. Plate 19 shows the type in use at the naval ammunition depot at St. Juliens Creek. Figure 61 shows a loose and stacked section of a 14-inch charge. For loose charges a small opening is left in the end of the bag-filling, this opening being stitched up after filling. With stacked charges the end is left off, as the bag must be pulled over a brass cylinder which holds the powder grains. The end is sewed in place afterwards by a special sewing machine. Stacked charges are also laced up to make them more compact. The arrangement of rows and number of grains in a row is so fixed that the finished section will have the length fixed by the table in Chapter 11. This arrangement differs with each index and is found by actually loading a test charge.

13. All operations requiring the exposure of powder to the atmosphere are carried out only when standard hygrometric conditions obtain. To insure this, psychrometer readings are taken frequently and work is discontinued when conditions are unsatisfactory, unless dehumidifying systems are installed in filling houses. By taking such precautions the ballistic regularity of the powder is not affected. Powder is always screened and sorted when weighed out, in order that powder dust, chips, and broken grains will not be included in the charge.

Chapter XV.

MISCELLANEOUS AMMUNITION.

Types of small arms.

1. Small arms ammunition includes the following:

30 caliber gallery, 1898, for gallery use in Krag rifles.
30 caliber gallery, 1919, for gallery use in Springfield rifles.
30 caliber dummy, 1898, for drill use in Krag rifles.
30 caliber dummy, 1906, for drill use in Springfield rifles.

NOTE.—The dummy cases have four perforations and are empty.

30 caliber blank, 1898, for ex-caliber use in Krag rifles.
30 caliber blank 1909, for 1903 and 1917 rifles for use with rifle grenade fitted with a stem.
30 caliber special tracer 1906, for model 1917 and 1918.
30 caliber ball 1906, Class A-1 and A-2, and B-1 and B-2.
30 caliber ball, 1918, for subcaliber in Krag rifle.
45 caliber ball C. A. P., for Colt automatic pistol.
45 caliber ball revolver.
38 caliber ball C. A. P., for automatic pistol.
38 caliber ball revolver, short or long, with black powder or smokeless powder.
38 caliber blank for revolver.
38 caliber, dummy, for revolver.
32 caliber ball for automatic (special for certain shore guards).
22 caliber ball for 22 rifle for Morris tube.

Issue of small-arms ammunition.

2. Small-arms ammunition is obtained from the Ordnance Department of the Army. It is issued by ammunition depots on order from the Bureau of Ordnance or on request of a commanding officer only for the purpose of filling allowances. When a request is forwarded to an ammunition depot, it should contain a statement that the material desired is "to fill allowance." Ammunition depots and ships and shore stations shall issue small arms for use from the oldest stock on hand, having regard for the conditions under which the ammunition will be fired and the division into classes and grades explained later. Care shall be taken not to break open air-tight small-arms containers unnecessarily and in excess of the immediate requirements. All boxes are hermetically sealed and when broken open and returned to storage more rapid deterioration of powder results and cases and bullets become foul with verdigris. Special stowage arrangements are required for small arms as explained in chapter 17.

PLATE XX.

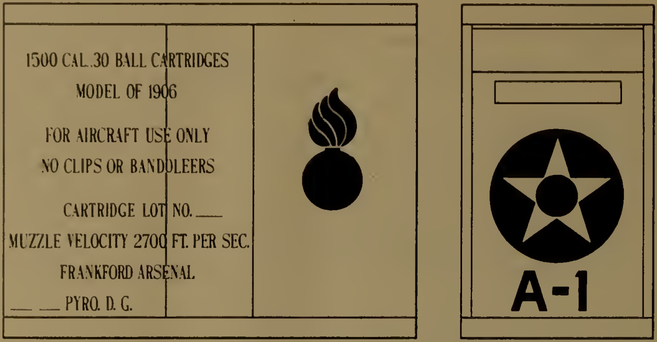


FIG. 1.

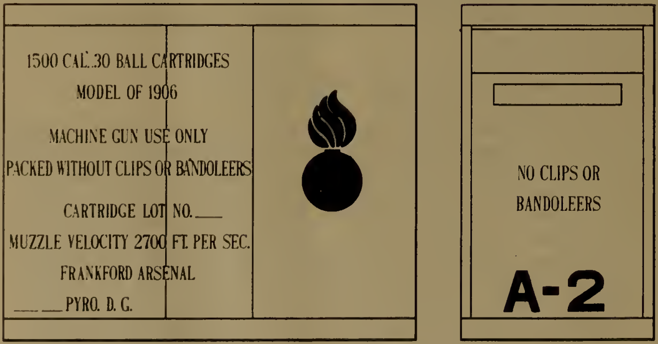


FIG. 2.

Containers for small Arms Ammunition. Air Craft and Machine Guns (without clips).

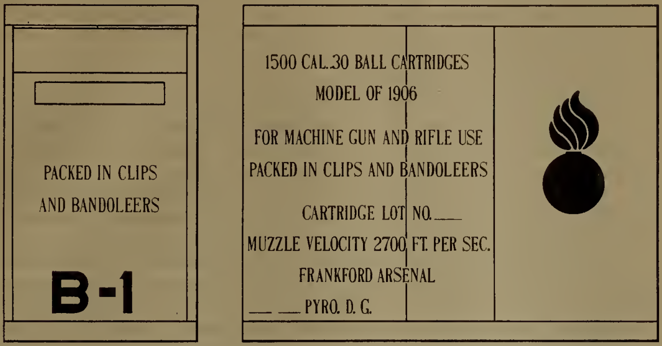

PACKED IN CLIPS
AND BANDOLEERS
B-1
1500 CAL..30 BALL CARTRIDGES
MODEL OF 1906
FOR MACHINE GUN AND RIFLE USE
PACKED IN CLIPS AND BANDOLEERS
CARTRIDGE LOT NO.___
MUZZLE VELOCITY 2700 FT. PER SEC.
FRANKFORD ARSENAL
___ ___ PYRO. D. G.

FIG. 1.

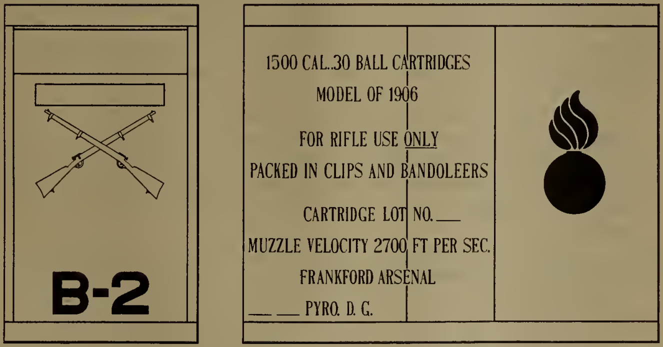

B-2
1500 CAL..30 BALL CARTRIDGES
MODEL OF 1906
FOR RIFLE USE ONLY
PACKED IN CLIPS AND BANDOLEERS
CARTRIDGE LOT NO.___
MUZZLE VELOCITY 2700 FT PER SEC.
FRANKFORD ARSENAL
___ ___ PYRO. D. G.

FIG. 2.

Containers for Small Arms Ammunition, Machine Gun and Rifle (with clips).

Care in handling.

3. Considerable difficulty is experienced at naval ammunition depots due to ships turning in small-arms ammunition partially or totally unfit for reissue. The following conditions are reported:

(*a*) Large numbers of boxes broken open and air-tight seals broken.
(*b*) Cartridges in clips with no bandoliers.
(*c*) Cartridges in wet bandoliers.
(*d*) Cartridges and clips corroded.
(*e*) Large quantities of loose ammunition not capable of being identified.

Ammunition depots can not handle this material economically, and, as a result, a considerable amount is a financial loss. These conditions can be avoided by care in issuing and stowing small-arms ammunition.

Classes and grades.

4. The Bureau of Ordnance follows the practice of the Ordnance Department of the Army in identifying small-arms ammunition; 30-caliber small-arms ammunition is divided into classes to show the method of packing and use. According to the latest practice five classes are used, designated by the symbols, "A–1," "A–2," "B–1," "B–2," "C–1." The letter "A" indicates "Packed in cartons." The letter "B" indicates "Packed in clips and bandoliers." The letter "C" indicates "Packed in expendable belts." The grades are indicated by the numerals 1, 2, and 3. Grade 1 is ammunition of the best quality in service and may be expected to stand storage for several years without deterioration. It should be expended only when no grade 2 is available. Grade 2 represents ammunition of a good quality at the present time, but with indications that it will deteriorate more rapidly than grade 1. It should be used up for current issue before using grade 1, and should not be issued to foreign stations or to ships leaving for extended cruises. It is most desirable to use this grade up and retain grade 1 for future requirements. Grade 3 contains all unserviceable ammunition and is not issued to service.

A–1.—Special ammunition packed in cartons for aircraft use. This class is especially selected under stringent requirements, and is given a 10 per cent gauging test for such defects that might in any way affect its functioning in aircraft machine guns. Only this class will be issued for use in synchronized machine guns to be fired while in flight, as it has been tested for hangfire to determine its desirability for use.

A–2.—For machine guns, packed in cartons, for general use except for synchronized guns and foreign stations. This class will be issued before class A–1.

B–1.—Machine gun (except for aircraft) and rifle ammunition, packed in clips and bandoliers. Service ammunition should be supplied from this class.

B–2.—Rifle ammunition, packed in clips and bandoliers, for general use in rifles to be issued for current use before using B–1 for rifle use. All target-practice ammunition will be taken from this class.

C-1.—Machine-gun ammunition, packed in expendable belts. This ammunition corresponds to class B–1.

Marking of small arms.

5. The markings on small-arms containers is shown on Plates 20 and 21. Boxes having only the following marks, "For aircraft or any other use," and "For aircraft use only," will be used as B–2 ammunition. Certain ammunition marked B–1 and B–2 may give sufficient hangfires to make its use in rifles dangerous. It may, however, be safely used in machine guns. When information of this condition is received, the boxes shall be remarked "B–2 for machine gun use only." The Bureau of Ordnance will issue circular letters as information is received, giving details of the transfer of lots of small arms from one grade to another. When information is received that any lot is designated as grade 3, it shall be turned in to the nearest naval ammunition depot for replacement by serviceable ammunition, as may be necessary.

Special uses.

6. Instructions regarding the care in returning empty cases is given in chapter 1. It is to be noted that a special blank cartridge is required for use with a rifle light and service 30-caliber ball cartridge with a rifle grenade. All incendiary ammunition has recently been withdrawn from service. Tracer ammunition is used in machine guns. Armor-piercing projectiles are designed for aircraft use only.

Shotgun ammunition.

7. Shotgun ammunition of standard commercial quality is supplied for training aviators. It should be given the usual care of this class of material. Ten and twelve gauge sizes are obtained. The 12-gauge ammunition has 3½ ounces of 7½ chilled shot and is loaded in accordance with the usual commercial practice with infallible, ballistite, or a similar powder. A special class of 12-gauge ammunition is supplied for shotguns loaded with 00 buckshot for use of guards at prisons, radio stations, and certain other naval stations. Under *no* circumstances should a Very signal be fired from a shotgun.

Torpedo impulse charges.

8. Torpedo impulse charges are made up aboard ship by using the spherohexagonal powder (shipped in bulk) in the impulse cases provided. Plate 22 shows the torpedo impulse cartridge case. The amount of powder to be used is determined for the different sizes of torpedoes and issued to the service for the information of those requiring it. A lock primer is used for igniting the charge. Great care should be taken to keep the spherohexagonal powder containers air-tight, the loading done without wetting the grains, and the cartridges thereafter, until fired, properly protected from moisture. Black powder is hygroscopic in its action and rapidly becomes useless with the addition of moisture. Torpedo impulse cases should be thoroughly cleaned after firing, as the residue will cause corrosion.

Powder for torpedo impulse.

9. Formerly black cubical and spherohexagonal black powder of an old design was used for torpedo impulse charges. A new spherohexagonal powder, corresponding closely to the old design, has been obtained, but the old will be issued until exhausted. The latest powder has been found to have somewhat different ballistic properties from the old and the two will not be mixed. 0.25 of a pound of the new powder is approximately 32 pieces; 0.4 of a pound 51 pieces, and 0.6 of a pound 76 pieces.

Y-gun charges.

10. Y-gun charges are made up in standard 3-inch landing-gun cartridge cases with case percussion primers, Mark X, and the proper weight of the new sphero-hexagonal powder mentioned above (Plate 23). The cartridges are similar to blank cartridges, having a hair-felt wad about an inch thick on top of the powder and a cork plug on top of the wad. Distance pieces are used if required. The cork plug is then shellacked. Cartridges are issued in standard ammunition boxes or special Y-gun ammunition boxes, marked with one of the following legends:

No. 1 charges for Y gun, 1 pound, 50 yards range.
No. 2 charges for Y gun, 1½ pounds, 72 yards range.
No. 3 charges for Y gun, 2 pounds, 93 yards range.

11. Saluting ships are issued an allowance of saluting cartridges (usually 3-pounder or 6-pounder), and also a supply of powder, primers, felt wads, and cork plugs for the preparation of additional charges on board ship as may be required.

Instructions for the preparation of saluting ammunition.

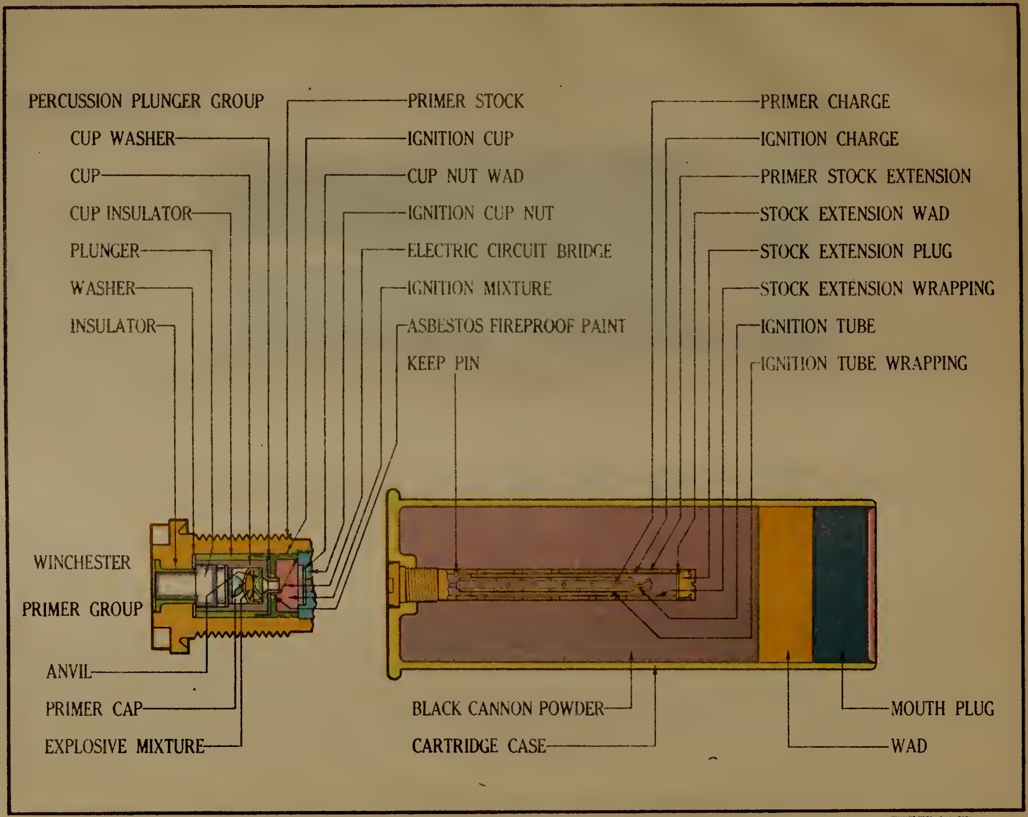
12. The following instructions regarding the preparation of saluting charges are issued for the guidance of ships and ammunition depots and must be strictly complied with. The ammunition details required for the preparation of these charges are issued to ships from the depots, and none but the authorized details may be used. The use of nonstandard primers, paper wadding, homemade plugs, etc., is forbidden.

Cartridge cases.

(*a*) Saluting cases are similar to service cases except that they are shorter, having the bottle neck cut off. They are ordinarily manufactured at the depots from service cases which have splits in the neck or other slight defects which render them unsuitable for service use. Before assembling, the cases should be carefully inspected to see that they are in sound condition and thoroughly clean and dry. They should also be tested by trying them in the gun to determine that they have not become deformed. Any cases which are damaged or which do not fit in the gun should be laid aside for return to a depot at first opportunity.

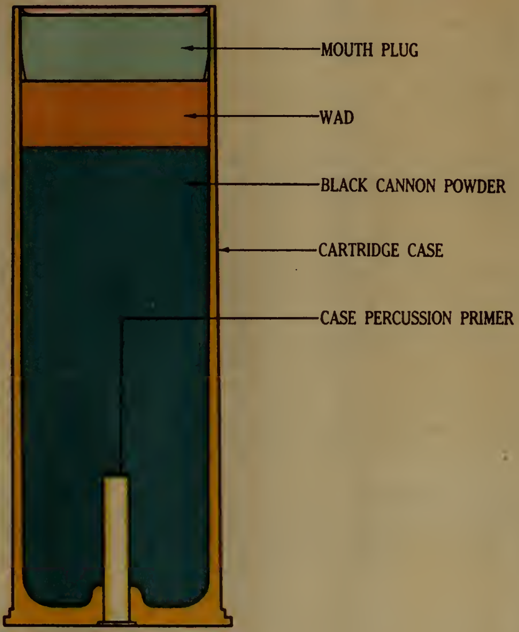
(*b*) Saluting cartridges for 1, 3, and 6 pounder guns and for 3-inch field and landing guns are primed with standard minor caliber cannon primers. After inspection and before loading the charge, the cases are primed. It is preferable not to prime cases until just before they are to be loaded. Primers should not be hammered in place, but should be pressed in, using the "repriming tool" shown on Ordnance drawing 41272. At least one of these tools is allowed each saluting ship. Care should be exercised that the primer is flush with the face of the cartridge case; if it is sunken in a misfire is likely, while if it protrudes a premature explosion may result. Cases should not be primed in the same room with black saluting powder or assembled charges.

(*c*) Standard black cannon powder is issued to ships in bulk in drums or tanks for use in the preparation of saluting charges. After priming, the cartridge case is filled with black saluting powder to within about 1¾ inches from the top. Immediately before loading the case should be inspected and thoroughly wiped out and freed from moisture before the powder is loaded. The powder is loaded directly in



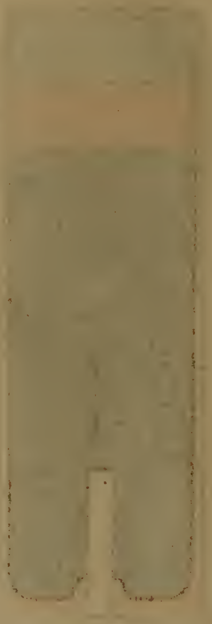
Torpedo Impulse Ammunition.

PLATE XXIII.



WILLIAMS-WEBB CO. INC. WASH. D.C.

Y-Gun Ammunition.



the case with the funnels provided, and special care should be taken not to spill any of the powder about, as this may become a source of serious danger. The normal weight of charge for the 3-pounder and 6-pounder saluting cartridges is about 1 pound, but it is preferable to fill the saluting cases furnished up to within 1¾ inches of the top, as specified above, rather than to attempt to load in a specific weight of charge.

(*d*) After loading the charge, as directed above, a hair felt wad about 1 inch in thickness and ⅛ inch larger in diameter than the mouth of the case is placed directly on top of the powder. These wads are specially manufactured and issued for use in the preparation of saluting cartridges, and are for the purpose of preventing fine grains of black powder from passing the wad. No substitute is authorized. Care must be taken that no grains of powder are left above the hair felt wad. On top of the hair felt wad is placed a cork plug specially furnished for the purpose. The cork plug should seat firmly on the hair felt wad, should be a tight fit in the mouth of the cartridge case, and when seated in place its top should be slightly below the upper edge of the cartridge case. Finally, the exposed surface of the cork plug and the inner edge of the cartridge case should be covered with a thick coating of shellac.

NOTE.—No great force should be used in pushing the cork plug into place, as pressure may force the primer out; if the cork plug will not enter readily, the felt wad should be taken out and some of the powder removed.

(*e*) Saluting ammunition should be prepared under the direct supervision of the gunner or other responsible officer, and before use should be critically inspected to determine the primers and plugs are properly seated, that the mouth of the case is properly shellacked, and especially that no grains of powder are adhering to the cartridges. When saluting, ammunition is prepared on board ship, new tags will be placed on the ammunition boxes, giving the initials of the gunner or other officer who supervised the work.

(*f*) As soon after firing as practicable, the fired primers should be removed from the cartridge cases by means of the decapping tool shown on Ordnance drawing 17410. The cases should then be thoroughly washed in a strong solution of lye or soft soap to remove all powder residue, and, after washing, thoroughly rinsed and then dried.

(*g*) An efficient solution for washing cartridge cases may be prepared by using ingredients in the following proportions: One gallon of water, 2½ ounces of soft soap, 5½ ounces soda. The mixture should be boiled and stirred until the ingredients are entirely dissolved. This solution should be used hot and in sufficient quantity to completely immerse the cases.

13. "Signal-gun charges" are occasionally issued for 3″/50 and 4″/50 guns for special purposes. These charges are put up in shortened service cartridge cases, and in general their method of assembly is similar to that described for saluting charges. These and other special blank charges will be issued to ships as required from ammunition depots and will not be prepared on board ship.

14. When empty, black-powder tanks and drums should be returned to a depot at first opportunity. Particular care must be taken that such empty drums have no black powder left in them.

15. Case charges assembled with mouth plugs and using black powder shall have the plug firmly fixed in place. In case of continued use, as in firing a salute, if mouth plug drops out, there is danger of igniting a part of the charge from the hot chamber and causing a premature explosion.

Stokes mortar ammunition.

Gre Let. X-258

16. (a) The projectile for the Stokes trench mortar differs from an ordinary pr jectile in that it contains, besides the fuse and burster charge, the propelling charg and cartridge. The firing pin is in the bottom of the barrel and when the projectil is dropped in with the cartridge edge down the cartridge cap strikes against th pin and fires. The projectile, Plate 24, consists of the projectile proper, whic includes the burster charge and fuse. The cartridge container is attached to the projectile and holds the cartridge, which is a 12-gauge shotgun shell. The cartridge container has radial holes for escape of gases and to allow the ballistite rings, whic are a part of the propellant powder charge, to become ignited.

Variable propellant charges.

17. To increase the range over that given by the cartridge alone, ballistite rings containing 100 grains of ballistite are used, either one, two, or three at one time. Never more than three rings are to be used at a time and this number only in cases of necessity. The following approximate ranges are what may be expected:

	Yards.
Minimum, cartridge alone	100
Maximum, cartridge alone	300
Maximum, cartridge with one ring	430
Maximum, cartridge with two rings	575
Maximum, cartridge with three rings	740

Precautions.

18. In firing a Stokes mortar the following precautions should be observed:

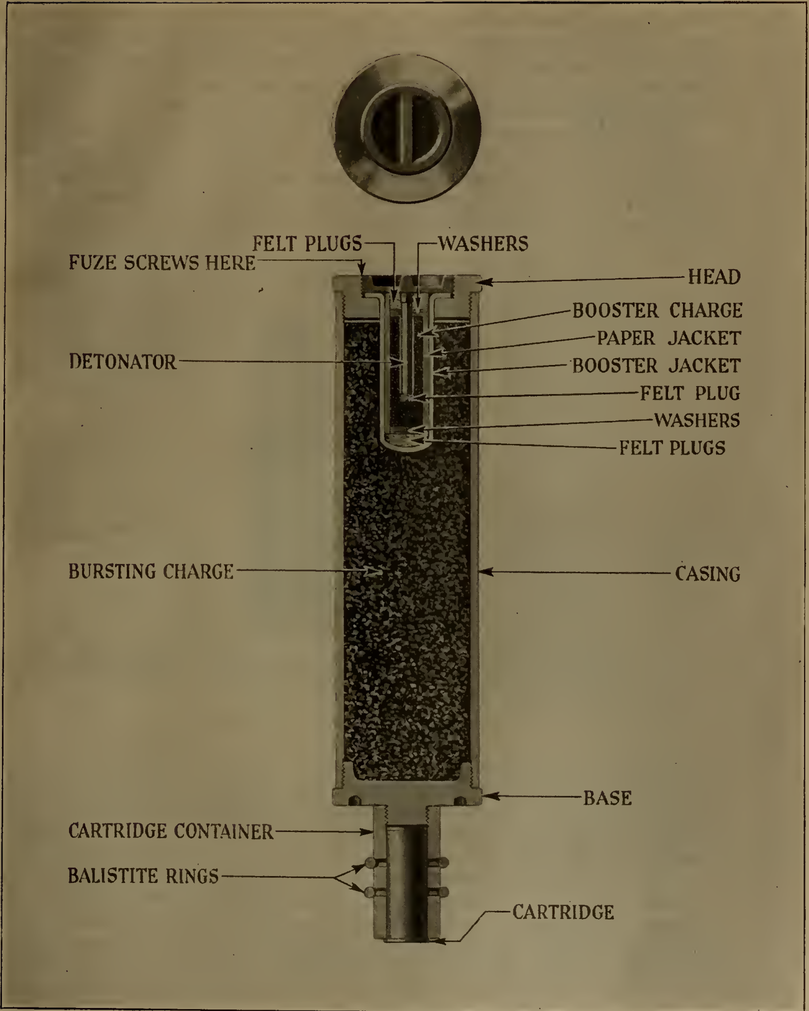
(1) See that the upper and lower flanges of projectile are clean.
(2) The cartridge must be a snug fit in the container.
(3) All oil must be removed from the bore.
(4) Never use more than three ballistite rings.
(5) Check position of mortar after firing.
(6) Remove safety pin from fuse just prior to loading. Misfire may occur from:

(*a*) Bad cartridges.
(*b*) Loose firing pin.
(*c*) Dirty flanges on projectile.
(*d*) Dirty bore.
(*e*) Bent cartridge container.

For information regarding burster charges, see chapter 8, rifle grenade.

Rifle grenades.

19. The VB rifle grenade fits in a special discharger attached to the muzzle of the rifle. When ^ a regular service cartridge is fired, the projectile hits the striker,



Stokes Trench Mortar Projectile.

which fires the primer and ignites the fuse. The grenade is ejected by the powder gases with a velocity sufficient to carry it 300 yards. ~~Another type not issued had~~ a ~~stem which fitted the bo~~re. A ~~special blank~~ cartridge ~~was used with this type, the pressure of the gases projecting the grenade a maximum distance of 350 yards. The range is regulated~~ by ~~the distance the stem is inserted in the bore~~.

20. The V B rifle grenade, Figure 62, is approximately 2½ inches in length by 2 inches in diameter and weighs, when loaded ready to fire, 17¼ ounces. The body is divided on the inside surface into 40 parts by deep grooves in order to insure proper fragmentation. The grooves are usually on the outside of grenades, but on account of the discharger used in firing the V. B. grenade an inside division by grooves is necessary, so that a close fit may be secured between the outside of the grenade and the discharger, thus allowing the gases from the cartridge to exert a maximum pressure on the base of the grenade in propelling it. If the grenade were grooved externally, the gases would escape through the grooves and most of the pressure would be lost.

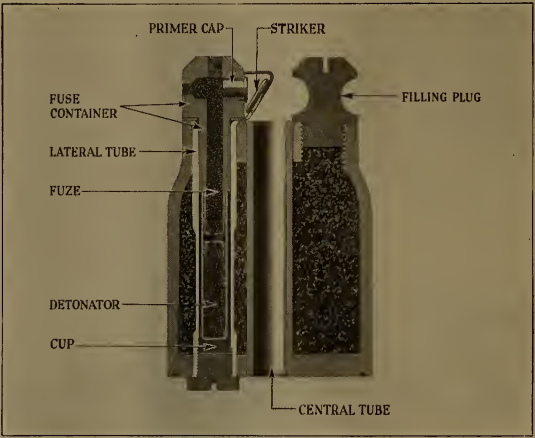


Fig. 62.—Cross Section V. B. Rifle Grenade.

21. The central tube and the lateral tube are expanded into the machined holes of the body, the central tube having its ends beveled on the inside to permit the free passage of the bullet. The walls of the lateral tube are made thin at the point which surrounds the detonator to insure its bursting when the detonator explodes. This tube is carefully reamed at the upper end to a size that will insure a tight fit with the fuze container and its lower end is tapped to receive the screw plug which holds the detonator in position by means of the intervening soft rubber cup.

22. The fuse container is provided with a hole for the primer, a loading hole in the top through which the meal and loose powder are inserted, and a vent opposite the primer. After loading the fuse the loading hole and vent are plugged with wax plugs to protect the powder train. These plugs are blown out by the explosion of the primer, thus affording an ample vent for the gases from the fuse and preventing a premature bursting of the grenade, which would be caused by the gases reaching the detonator. The fuse container, which is machined on the lower end to a size which will allow the upper end of the detonator to fit over it, is forced into the lateral tube through the hole in the end of the striker, and thus holds the latter in position. The striker is punched from sheet steel.

23. One end of the detonator is left open. This end is inserted in the lower end of the lateral tube and overlaps the lower end of the fuse container. The rubber cup is then placed over the lower end of the detonator and both parts are held in position by the screw plug. This arrangement of the detonator at the top and the rubber cup at the bottom prevents the detonator from receiving any shock from the plug end or by being in too close contact with the walls of the lateral tube. It is entirely a safety device.

24. The grenade is loaded with the main charge through the loading hole and protected by the filling plug.

25. The discharger, rifle Mark IV, is the only discharger issued to the service. It is for use on the Springfield 1903 rifle and is to be used for both the rifle lights and the V. B. rifle grenades. It consists of a hollow stem, arranged to fit snugly over the muzzle of the rifle, surmounted by an enlarged hollow cylinder into which the grenade or rifle light is placed. The Ordnance Department of the Army has several types of dischargers, but none other than that described herein should be used on the 1903 Springfield rifle. The discharger is fitted on the muzzle of the rifle, a grenade is put in the discharger, and the rifle loaded with an ordinary 30-caliber ball cartridge. The rifle butt is placed on the ground or deck and pointed in the direction it is desired to fire. The grenade is now ready for firing. On firing the cartridge the bullet passes through the barrel of the rifle and through the central tube, forcing the striker against the primer. At the same time the gases from the chamber collect in the chamber of the discharger under the grenade and eject the latter from the discharger. The explosion of the primer ignites the fuse, which is timed to burn eight seconds, when it explodes the detonator and this detonates the main charge. It is recommended that grenades be fired singly.

26. (a) The dummy grenade is an iron casting with a hole through the center to represent the central tube of the live grenades. The weight is the same as the service grenade and is used in the same manner as the latter.

Service cartridges are not to be used with rifle lights in the discharger.

(b) The V.B. rifle grenade has been withdrawn from issue. At the present time no high explosive rifle grenades are available.

Hand grenades. 27. A hand grenade is a form of projectile thrown by the hand instead of by a gun. In a great number of grenades used the so-called Mills method of operation is employed. This principle involves the use of a lever which lies close to the body of the hand grenade and parallel to its longitudinal axis. Several types are made, but the only type to be used by the naval service is the offensive grenade. Figure 63 shows the construction. The body is a tube of laminated paper, wound spirally, about $\frac{3}{32}$ inch thick, and made in two parts, an inner and outer shell. The inner shell is impregnated and coated with paraffin. The entire body is then waterproofed. The top is metal—a lead alloy—and the bottom paper, both crimped in place. The firing mechanism, called the bouchon assembly, is screwed into the top. The bouchon assembly consists of the firing mechanism fuse and detonator. The bouchon is a lead alloy die casting, the striker rotates around the hinge pin by means of a spiral spring wound on the hinge pin. The striker is held down against the striker spring by the lever, which is a sheet metal stamping with a hooked lip to fit over a lug on the bouchon, and with two flanges pierced by holes for the split pin, which also passes through the bouchon. The primer is of a standard center type, similar to a 22-caliber, and is held in the

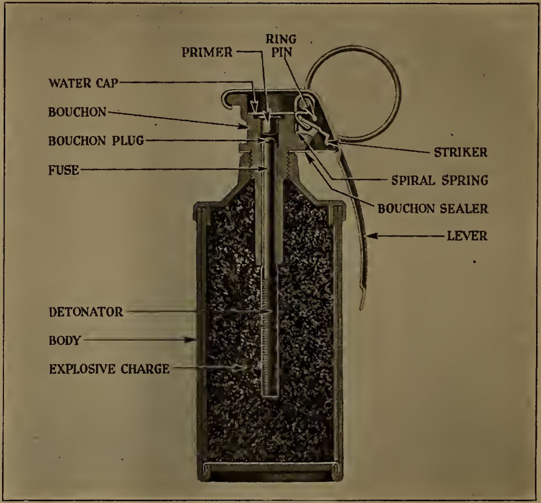


Fig. 63.—Hand Grenade.

Page 217, Paragraph 29 - Cross out and substitute the following:-

"Grenades and fuze assemblies except as specified are shipped separately and are to be assembled when desired for use. In the latest standard defensive hand grenade (loaded with E.C. powder) the fuze and ignition assembly is issued assembled in the grenade therefore no field assembly is required. In other types sufficient space in the body is provided to permit assembly of the firing mechanisms."

Hand grenades.

27. A hand grenade is a f
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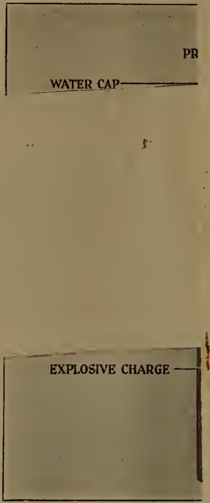

entire body is then waterproofed.
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bouchon by being pressed into place. A water cap covers the primer. The fuse is a piece of Bickford fuse with a fast composition on top and at bottom is the detonator. The fuse is timed to burn five seconds. The explosive charge surrounds the detonator.

28. To arm the grenade the bomber grasps the grenade and lever firmly in his throwing hand in such a manner as to secure the lever tightly against the body of the grenade. The first finger of the free hand is inserted in the split ring and the ring is gripped tightly between the second and third joints. Upon withdrawal of the split pin the grenade is armed and ready to be thrown.

The bomber must take every precaution not to release the grip on the lever until he throws the grenade.

As the grip is released the striker, actuated by the spring, rotates around the hinge pin, forcing out the lever, and strikes the primer sharply. The primer ignites the fuse through the fast composition and when the fuse has burned through it sets off the detonator ~~and~~ which explodes the grenade, or sets off the ignition compound, which ignites the charge as the case may be.

29. Grenades and bouchons are shipped separately and are to be assembled when desired for use. The grenade has a wooden plug in the top for the protection of the explosive. To assemble, remove the wooden plug, form a suitable cavity in the explosive with a wooden stick and insert the bouchon assembly and screw it home.

30. The grenade is of such a type that after the safety pin is removed it will arm the instant the lever is released.

READ CAREFULLY.

Remember that the hand grenade is always loaded and cocked. It is always pointed at you. It is a safe weapon when properly handled, but a very dangerous one when handled otherwise.

31. If you accidentally allow the striker to function, do not drop the grenade and run, but throw the grenade as far as you can and then throw yourself flat on the ground.

32. If you drop the grenade, pick it up and throw it. There is plenty of time if you do not hesitate.

33. Remember that the bodies of all hand grenades will be painted battleship gray when loaded (live).

34. The bodies of the defensive hand grenades which are used for practice (not loaded) will be painted bright red.

35. A live grenade should never be thrown unless cover is at hand, behind which the operator and spectators may secure shelter. A fragment may fly over 200 yards.

36. *Do not arm the grenade* by drawing the safety split pin. Unless the grenade is to be thrown at once, the split pin must *never be removed.* If the grip is accidentally released after the pin is pulled, the striker will be operated immediately and the grenade will explode.

AID - Jan 26
Page 216

(c) The Standard types of rifle grenades are: (1) Rifle Grenade, Smoke (W.P.) Mark I, requiring a Mark IX fuze assembly; (2) Rifle Grenade Lachrymatory (C.N.) Mark II, requiring a Mark VIII fuze assembly.

These grenades consist of three main units, (1) the fuze assembly (firing mechanism), (2) the loaded grenade body and (3) the rifle rod. These units are never issued assembled. A separate, special, caliber .30, blank cartridge is used as a propellant. Instructions for assembling are provided in the packing boxes.

(d) Operation of rifle grenades:

1. These grenades are of the "time" type in that they will not function until a certain fixed time has elapsed after being fired from the rifle.

2. To fire this type of rifle grenade proceed as follows: (1) Insert the rifle rod into the barrel of the rifle full length. (2) Remove the safety pin from the fuze assembly and be sure that the cover is thrown off. (3) Place the butt of the rifle on the ground and support it well. (4) Insert the special blank cartridge into the chamber of the rifle, check aim for elevation desired and then fire.

(e) Precautions:

1. Never attempt to use the rifle grenade as a hand grenade.

2. Use only the special, caliber .30 blank cartridges furnished for rifle grenades. The heads of these cartridges are stamped with the letters "CRG".

3. Fire from cover if possible.

4. Do not remove the safety pin until after the rifle rod has been inserted in the rifle and you are ready to fire.

5. Make sure that the cover is thrown off from the fuze assembly after the safety pin is withdrawn. If necessary remove it by hand.

6. Use only rifles of Springfield Armory manufacture bearing serial numbers greater than 800,000, or rifles manufactured at Rock Island Arsenal regardless of serial numbers.

7. The detonator in the Mark IX fuze assembly contains fulminate of mercury and is dangerous in itself.

8. A live grenade that has misfired should be recovered only by someone who understands the mechanism thoroughly. At least ten minutes should elapse after firing, before approaching or touching the grenade.

9. Do not disassemble a grenade that has failed to function. If such procedure is necessary it should be done by an expert.

Page 216, Paragraph 27. Cross out entire paragraph and substitute the following:-

Hand Grenades:

(a) The offensive hand grenade Mark III is now obsolete.

(b) The following are the three standard types in use:

I. Defensive.
II. Tear Gas (Lachrymatory).
III. Phosphorus.

The two principal parts of the hand Grenade are (1) the body, consisting of a lemon shaped container which holds the main charge of explosive, or gas, etc; and (2) the firing mechanism, known either as the Fuze (formerly called Bouchon) and Detonator assembly or the Fuze and Igniter Assembly, a device which starts the functioning of the grenade.

(c) Firing mechanism.- This comprises a fuze body consisting of a head and stem, a primer cap, a firing pin, and a striker The cap, firing pin and striker are assembled in the head of the fuze body. Into the stem is inserted a short piece of Bickford time fuse to which is attached either a detonator or an ignition charge. The time fuse is designed to burn 5 seconds.

(d) Two kinds of detonators are used in fuze and detonator assemblies: (1) a No. 6 detonator consisting of a standard No. 6 blasting cap, $1\frac{1}{2}$ inches long, which projects below the fuze body stem $1\frac{1}{4}$ inches; and (2) a No. 8 detonator consisting of a standard No. 8 blasting cap, 2 inches in length, which projects $1\frac{3}{4}$ inches below the fuze body stem. The No. 6 detonator is used in the defensive hand grenade (if loaded with H.E.); while the No. 8 detonator is used in phosphorus grenades. The necessity of a clear distinction between the fuze assemblies with No. 6 and those with No. 8 detonators is due to the fact that, the use of fuze and detonator assemblies with the wrong size detonator may result in mal-functioning and possible danger. A special ignition, without detonator, is used in the lachrymatory type grenade, and also in the defensive hand grenades when loaded with E.C. powder.

(e) The standard types offuze and Detonator Assemblies are as follows:-

(1) Fuze and Detonator Assembly Mark V No. 6 is provided with a time fuse and a No. 6 detonator, for use in Defensive hand grenades Mark II (unless otherwise specified).

(2) Fuze and Igniter Assembly Mark X is a modification for use with the grenade, hand, fragmentation, Mark II of new manufacture (grenade contains charge of (E.C.) powder in place of high explosive formerly used.)

(3) Fuze and Detonator Assembly Mark V No. 8 is provided with a time fuse and a No. 8 detonator, for use in the grenade, hand smoke (W.P.) Mark II.

(4) Fuze and Igniter Assembly Mark VII is provided with a time fuse and ignition charge for use in grenades, hand, lachrymatory (C.N.) Mark V.

Note:- The fuze assembly Mark V is a modification of the old Mark II of which there are a few in service.

Page 217, Paragraph 29 - Cross out and substitute the following:-

"Grenades and fuze assemblies except as specified are shipped separately and are to be assembled when desired for use. In the latest standard defensive hand grenade (loaded with E.C. powder) the fuze and ignition assembly is issued assembled in the grenade therefore no field assembly is required. In other types sufficient space in the body is provided to permit assembly of the firing mechanisms."

37. Do not assume that you can guess when five seconds have elapsed and try to function the grenade a moment or so before throwing. You will surely get caught some time if you do so.

38. *Unless you remember these warnings and act accordingly you and your comrades will become the victims of your carelessness.*

39. The detonator or firing device is dangerous in itself. Its size is no indication of its power, for it is powerful enough to blow one's hand to pieces.

40. The detonator contains a small charge of fulminate of mixture. This explosive is very unstable, and the slightest jar or a sudden change in temperature may be sufficient to cause explosion. Consequently the only safe thing to do is to treat all detonators with proper respect.

41. The live grenades are painted battleship gray. They weigh 10¾ ounces each and are packed 48 in a box. The explosive is Trojan powder (see ch. 7) or T. N. T. The dummy grenade is cast iron, with a projectile cast on the side to represent the lever. It is used for practice in throwing. The practice grenade is similar to the live grenades, except that the explosives are removed. The regular bouchon assembly with live primers are used for more advanced training than with dummy grenades.

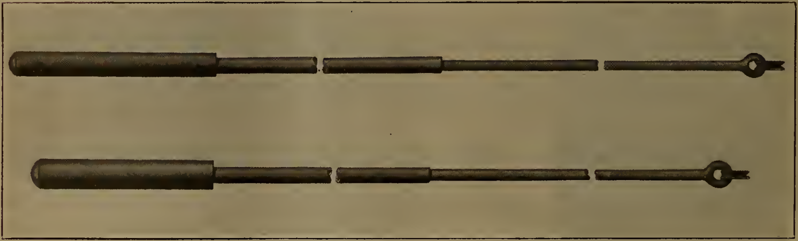


Fig. 64.—3 and 6 Pounder Line-Throwing Projectile.

42. More detailed information may be obtained from pamphlets on rifle and hand grenades and trench mortars issued by the Ordnance Department of the Army, copies of which may be obtained from the Bureau of Ordnance.

43. Trojan powder is very hygroscopic and as it absorbs moisture becomes less and less powerful until its explosive qualities are *nil.* There is no evidence that in this process there is a loss of stability. Absorption of moisture is shown by the appearance of the cardboard body. If sufficient moisture is absorbed, metals in contact with the Trojan powder will suffer corrosion. Should the metal of the detonator corrode through and free the fulminate of mercury, there is a possibility of the grenade becoming dangerous. Occasional inspections should be made for moisture, and such as show signs of deterioration should be turned in to an

Page 218, Paragraph 42, delete and substitute the following:-

Disposition of Phosphorus Rifle and Hand Grenades:

(a) Due to the fact that phosphorus-filled rifle and hand grenades have been found dangerous for indefinite continued storage, it has been found necessary to prescribe a limiting time within which [illegible]

, the packing box will be marked with the limiting date within which the grenades must be used. This date will not exceed 12 months after the date of issue from a manufacturing arsenal or storage depot [illegible] issued grenades. For grenades remaining

only [illegible] sue
of such materi[illegible] o-
jectiles loaded with Tro[illegible] ed
and withdrawn from service.

Page 218, Paragraph 41. Cross out and substitute the following:-

"Hand grenades, fragmentation, Mark II with (E.C.) charge are packed 10 in a box with fuze assemblies, ignition type, assembled. Other types are packed 24 in a box without firing mechanisms or fuze assemblies."

Markings:

Grenades, hand, fragmentation, Mark II are painted yellow (old markings battleship gray).

Grenades, hand, smoke, W.P. are painted blue gray with one yellow band $\frac{1}{2}$ inch wide around the equator of grenade. Also applies to rifle grenades, (W.P.) type).

Grenades, hand, Lachrymatory (C.N.) are painted blue gray with one green band around the equator of grenade. (Also applies to rifle grenades (C.N.) type.)

"The dummy hand grenade is cast iron with a projection cast on the side to represent the lever. It is used for practice throwing. For more advanced training the standard practice hand grenade known as grenade, hand, practice, is used. This comprises a defensive hand grenade body to which is assembled a fuze and Detonator Assembly Mark V No. 6. The grenade is empty and the metal plug in the bottom of the grenade body is omitted."

moisture, and such as show signs of deterioration should be turned in to an

Page 218, Paragraph 42, delete and substitute the following:-

Disposition of Phosphorus Rifle and Hand Grenades:

(a) Due to the fact that phosphorus-filled rifle and hand grenades have been found dangerous for indefinite continued storage, it has been found necessary to prescribe a limiting time within which such grenades must either be expended or destroyed. The phosphorus grenades now approved for issue are known by the following nomenclature:

Grenades, Rifle, Smoke, W.P., Mark I
Grenades, Hand, Smoke, W.P., Mark II

(b) The danger in storage of these grenades is principally due to the rusting of the metal containers which eventually exposes the phosphorus grenade filler to the action of the air, resulting in spontaneous combustion. Therefore, all stocks of this material in storage should be isolated insofar as practicable in order to prevent excessive damage in case spontaneous combustion should occur. The grenades in stock should be frequently inspected to detect any evidence of incipient combustion. Leaky or smoking grenades should be immediately submerged in a pail of water, using precaution to avoid burns in handling, and thence removed from storage and destroyed.

(c) Hereafter when phosphorus grenades are loaded and accepted for issue, the packing box will be marked with the limiting date within which the grenades must be used. This date will not exceed 12 months after the date of issue from a manufacturing arsenal or storage depot to a unit for issued grenades. For grenades remaining

only when it is clear that conditions warrant the issue of such material. All grenades and trench mortar projectiles loaded with Trojan powder have been condemned and withdrawn from service.

moisture, and ~~such~~ as show ~~signs~~ of deterioration ~~should~~ be turned ~~in~~ to an ammunition depot for survey.

44. Line-throwing

in storage depots and not issued, the date will not exceed 18 months from the date of original packing or subsequent inspection. Before the expiration of the 18 months period the phosphorus grenades still in storage will be subjected to a thorough inspection and those found serviceable will be repacked and restencilled for another 18 months period. This procedure will be continued until the grenades are issued or through a subsequent inspection have been found unserviceable and destroyed. The limiting date within which issued grenades shall be expended will be stencilled on the boxes by the issuing depot at the time of issue. As noted above this date will not exceed 12 months.

(d) When it is found necessary to destroy phosphorus grenades, the following procedures are recommended:

1. A pit should be prepared about two feet square and not less than three feet deep. On the bottom of the pit sufficient fuel should be placed to insure a hot fire and not more than fifty grenades should be placed on top of this combustible material. Care should be taken to insure that detonators to be destroyed are assembled in the grenades. The fire should now be lighted and all personnel should retire to a safely barricaded shelter or to a distance of not less than 100 yards, as detonations may occur scattering the burning phosphorus for a considerable distance in all directions. After the fire is lighted no attempt should be made to investigate the pit until the fire has burned entirely out and the pit is cold.

2. By dumping overboard in deep water.

Page 218 - Delete paragraph 43.

Substitute: Paragraph 43:

"The use of live grenades is dangerous to untrained personnel and consequently service grenades will not be issued except to trained personnel of the Navy and then only when it is clear that conditions warrant the issue of such material. All grenades and trench mortar projectiles loaded with Trojan powder have been condemned and withdrawn from service.

oisture, and ~~such~~ as show ~~signs of deterioration should be turned in to an ammunition~~ depot for survey.

Line-throwing ammunition.

44. Line-throwing equipment for use of vessels afloat is provided as follows:

(*a*) For vessels carrying saluting guns, 3 and 6 pounder line-throwing projectiles and charges.

(*b*) For destroyers and tugs, 45-caliber line-throwing guns and ammunition.

Figure 64 (drawings 53071 and 54762) shows the 3 and 6 pounder line-throwing projectiles. The lines are supplied by the Bureau of Construction and Repair.

Preparation of charges.

45. In using the line-throwing 3-pounder and 6-pounder projectiles, the line is prepared, faked down near the muzzle of the gun, and the end is attached to the thimble in the end of the spindle. About 2 fathoms of the line from the end is wet down. The projectile is loaded in the muzzle and fitted in the case and the case then loaded. The line should then be cleared for running out. It is preferable to use the lines provided, but if these should not be available, a soft, pliable line of the required size will be satisfactory. The same precautions should be taken with the cartridge as for other types. The charges are prepared as for saluting charges. The following weights of charge of black cannon powder are assigned:

3 pounder.	6 pounder.
250 yards, 8 ounces. 300 yards, 10 ounces.	300 yards, 9 ounces. 350 yards, 12 ounces.

46. It is difficult to control the range by varying the weight of charge. Not less than 6 ounces nor more than 12 ounces shall be used for the 3-pounder and not less than 9 ounces nor more than 13 ounces for the 6-pounder projectile. The projectile may be fired without fitting it in the case, but less regularity will then be obtained.

47. The 45-caliber line-throwing gun is shipped in boxes containing 50 cartridges, 10 projectiles, 4 lines, spindles, cleaning gear, and book of instructions.

Chapter XVI.

AIRCRAFT AMMUNITION.

1. Aero bombs are classified as follows: Aero bombs.

Fragmentation bombs.
Demolition bombs.
Incendiary bombs.
Antisubmarine bombs.
Armor-piercing bombs.
Smoke bombs.
Gas bombs.
Dummy bombs.

2. A fragmentation bomb, Chapter XVIII, is a small one for use against personnel. The shape, distribution of metal, and weight of charge are designed to give the most efficient fragmentation and the best distribution of fragments. The fuze must be very quick acting in order to obtain detonation before the bomb has buried itself in the ground. The Navy in general will have only limited use for a fragmentation bomb. The development of this type has been assigned exclusively to the Army, and all fragmentation bombs required will be obtained from the Army or manufactured according to their designs. For details of Army bombs Army publications will be consulted. Fragmentation bombs.

3. A demolition bomb is a general-purpose bomb, the development of which has been assigned to the Army. They will be made in sizes of approximately 100 pounds, 250 pounds, 500 pounds, 1,000 pounds, 2,000 pounds, and 3,000 pounds. These bombs must have a case sufficiently strong to penetrate the average unprotected structure (arsenal, factory, etc.) but the weight of explosive is kept between 50 per cent and 60 per cent of total weight even if penetration is sacrificed. Fuses are fitted with various interchangeable delays. A heavy case type with less bursting charge may be used in weights of 100 pounds, 250 pounds, and 500 pounds for use against factories, in order to give fragments which would damage machinery, etc., removed from the blast effect. Demolition bombs.

4. These bombs are well adapted to use against submarines if fitted with a fuse to function instantaneously on impact or with a delay action on water impact. The heavy case type may find a use against capital ships with a fuse allowing only enough delay for the bomb to penetrate light decks if it is solid enough to do so without breaking up. The fuse in any case for naval use should function on water impact, and in this case have enough delay to reach a depth where the mining effect would be good.

5. Army publications will be consulted for data on Army demolition bombs.

Incendiary bombs.

6. The incendiary type of bomb has also been assigned to the Army for development and will probably be little used in the Navy. Army publications will be consulted when required. Two types are in use, the scatter type and the intensive type. One of the scatter type consists of a number of small bombs dropped in a case which opens up in flight, scattering the small bombs. In general thermit has been the incendiary material used.

Antisubmarine bombs.

7. This type has been assigned exclusively for development to the Navy. The case is as light as practicable, admitting of a high percentage of explosive. The fuse must function instantaneously on direct impact and with a delay on water impact that will allow the bomb to reach a depth where its mining effect is serious. This type of bomb is very similar to the demolition bomb. To admit of general naval use a development may be a heavier case bomb able to penetrate a light deck with a very short delay on solid impact. The Marks IV, IV–1, V, and the 520-pound Mark I are present examples, and are now fitted with the Mark VI fuse. Bureau of Ordnance pamphlets will be consulted for detail information. The sizes made will approximate 250 pounds, 500 pounds, 1,500 pounds, and intermediate or larger sizes if required.

Armor-piercing bombs.

8. In an armor-piercing bomb the design must be best for penetration and at the same time most carefully stream lined for the minimum resistance in order that the highest practicable velocity may be obtained from the given height. A bomb of this type will be in the nature of an armor-piercing projectile, with light streamlined tail cone and vanes. The percentage of explosive is not apt to exceed 10 per cent at most. Due to the fact that at moderate altitudes the velocity attained is not high enough to penetrate very heavy decks, a development is likely to be a bomb without explosives but with means for increasing the velocity.

Smoke bombs.

9. These are for laying smoke screens. A 50-pound size has given satisfactory results and the bomb will be made in larger sizes. The smoke material constitutes a fire risk and as far as practicable these bombs should be treated like smoke boxes.

Gas bombs.

10. The development of these has been assigned exclusively to the Army. Gas material may be combined with other types of bombs.

Dummy bombs.

11. It is desirable to have all bombs follow the same trajectory. Studies of form and air resistance are under way with this as a possible result. The weight, however, varies as the cube of a linear dimension and the resistance as the square in the cases of geometrically similar bombs, so that to obtain a single trajectory small bombs must be carefully stream lined and large ones must have accurately determined resistance deliberately added. Concrete dummy bombs have been made to represent certain particular bombs.

12. A small miniature practice bomb is in extensive use and is satisfactory for work at low altitudes. Its trajectory approximates that of larger bombs and altitudes up to three or four thousand feet. This bomb is loaded with a 10-gauge blank shotgun shell, which by the smoke or spray caused shows the position of fall.

A disk with a firing pin attached is held away from the shotgun cartridge by a light spring. On impact (solid or water) the disk is driven back and the cartridge is fired.

Care and handling of aero bombs.

13. The charge of an aero bomb is in general cast T. N. T., though other explosives, notably amatol, have been used. This puts the bomb in the same class as mines and torpedo war heads as far as care and handling is concerned. See data in other chapters.

14. The 230-pound Mark I aero bomb has a central tube which contains boosters of grade A, T. N. T. and tetryl. The pistol itself is simply a plunger and firing pin held away from the detonator by a light spring. When on a plane a small propeller is screwed on the end of the firing pin plunger and prevents movement. Additional safety is provided by a cotter pin (removed before plane leaves ground) through the plunger. The detonator of these bombs will not be put in place in the bomb until the bomb is on the plane, but the bomb can be shipped with boosters (exploders) and pistol (sometimes erroneously called the fuse) in place. The detonators are packed, shipped, and stowed separately as detonators. See chapter on detonators and Bureau of Ordnance Pamphlet No. 45. Small numbers of other bombs with this type of detonator and exploder or booster are in the service.

15. Certain of the 230-pound Mark I bombs were obtained from British sources, and these as obtained had a detonator in each end of each exploder. In handling these bombs all detonators must be out, and extreme care will be used in removing detonators and exploders of bombs that have been put on planes and are to be returned to stowage.

16. The Mark VI fuse is used in all other bombs now issued to the service. This fuse is safe to leave in the bombs for handling, stowing, and for transportation by Government transportation in the immediate vicinity of naval ammunition depots. For other transportation the fuse will be removed and a wooden plug put in its place. All bombs using this fuse have a large secondary booster of granular (grade A) T. N. T. at the end of the bomb around the fuze. In removing the wooden plug care will be taken not to loosen this grade A, T. N. T. If practicable, without damaging or distorting tail vanes, the bomb will be stood on its tail. Care will be taken to allow no air gap between the fuse and this secondary booster. Ordnance Pamphlet No. 42 describes the Mark VI aero bomb fuze and method of inserting in Marks IV and V bombs if received with old fuses.

17. Bomb using Mark VI fuses should be inspected occasionally to make sure the detonator is in the safe position and the propeller is locked against rotation. The propeller should be turned a few turns and then brought back to about one-half turn from extreme movement to safe position to insure freedom of rotation and absence of verdigris on screw of shaft.

18. Mark VI fuses not in bombs should be treated as detonators. See chapter on detonators.

Marking and painting bombs. **19.** See Chapter XVIII on marking and painting of ammunition.

Machine-gun ammunition. **20.** Only ammunition classed as A–1 should be used in aircraft machine guns. See Chapter XV "Small-arms ammunition."

Pyrotechnics. **21.** See Chapter XIX, "Pyrotechnic materials." Wing tip or landing flares (Holt flares) have been in use but are being superseded by electric searchlights.

22. The present type of parachute flare (the Army airplane flare Mark I or the Michelin flare) has been obtained from foreign services or the Army. Army publications should be consulted.

23. A small pyrotechnic grenade to take the place of the Very pistol and cartridge is under development.

Torpeodes. **24.** Torpedoes used from aircraft are very similar to other torpedoes, and the same instructions apply.

Chapter XVII.

STOWAGE OF AMMUNITION.

Stowage regulations.

1. The following provisions shall be carried into effect in the stowage of ammunition:

Smokeless powder.

2. As far as practicable, smokeless powder for different calibers shall be stored in separate magazines. It frequently happens that changes in armament require the storage of different calibers of approximately the same size together. It is the intent of this provision not to stow large and small caliber powders together, but, if impracticable to do otherwise, it is not seriously objectionable, for instance, to stow 3″/50 and 3″/23 cartridges in the same compartment, although, when the necessity for such action arises, the question should be referred to the bureau for decision. However, bag charges and case ammunition must always be stowed separately.

Powder charges.

3. Projectiles and powder charges, except case ammunition, shall not be stored in the same magazine. In the event of a magazine blowing up, large caliber projectiles would work considerable havoc if their fuses were detonated, due to their size and the magnitude of their burster charge.

Case ammunition.

4. Case ammunition containing primers shall be stored in magazines by itself. The reason for this is that each charge contains within itself the complete train for creating an explosion, requiring only an external agent to initiate the action. In this connection, it must be remembered that primers in cartridge cases should always be protected. Care shall be taken in handling assembled case ammunition out of their containers not to strike the percussion cap against anything sharp. In rapid loading care should be taken in handling cartridges so that the point of a projectile will not accidentally strike the cap of a primer of another case; consequently, it is well to have the loader hold his hand over the base of the case.

Black powder.

5. Black powder, except attached ignition charges, shall be stored in a separate magazine, if practicable.

6. As black powder is a very dangerous explosive, it should always be kept by itself and only in such quantities as will meet the immediate needs. This explosive remains stable and chemically unchanged indefinitely and no stability tests are required. However, it is necessary to protect the powder from dampness and to see that it does not cake or otherwise change in physical properties. Care shall be taken that no loose powder is allowed to remain on screw threads of the opening in black powder drums. Black powder containers shall not be opened in the magazine. The greatest care should be exercised to prevent sparks from any cause when handling loose black powder. Torpedo impulse powder may be stowed in the same magazine with small-grained black powder. Baize cloth or similar soft material shall be spread on deck when handling bulk black powder, to prevent the ignition of a grain by friction under foot against a hard surface.

Small arms.

7. Small-arms ammunition shall be stored in a separate magazine, if practicable.

8. Due to the small powder charge in small-arms ammunition and to the difficulty of keeping it under as close an observation as for large-grain powders, the same reliability can not always be expected of it. Also, due to the difficulty of getting accurate results from tests afloat, ships are not required to test small-arms ammunition. Therefore, by keeping small-arms ammunition by itself any effect of deterioration of powder would be localized, as, due to the small amounts of explosives involved, if exploded little damage would occur, but if accidentally exploded in the presence of a larger caliber powder it might cause considerable damage.

Detonators.

9. Dry guncotton or detonators shall not be stored below the water line.

10. Dry guncotton is rarely met with in service now, as torpedo and mine boosters are all granular T. N. T. When the requirements for the Navy for T. N. T. boosters have been met, it is probable that the dry guncotton will all be scrapped. Detonators are very sensitive and if exploded in a closed compartment would cause considerable damage, and furthermore, they are subject to detonation when not in contact. Consequently, it is required that they be stowed above decks and in separate storage spaces.

High explosives.

11. Torpedo warheads, mines, and depth charges shall be stored only in the approved designated places.

12. These are mainly classed as fire risks, for the charge will not explode unless detonated. However, T. N. T. after taking fire will, if there is sufficient present to maintain combustion 15 minutes, then detonate. Consequently, nothing should be stored with these objects which could start a conflagration.

Bombs.

13. Aero bombs shall be stored in mine rooms or magazines designated for the storage of similarly loaded ordnance material.

14. As bombs are loaded with T. N. T. or a similar material, they fall into the class of insensitive high explosives loaded ammunition. Army bombs may be loaded with other substances than T. N. T., such as mixtures including nitro starch or ammonium nitrate, thereby requiring closer observation than for standard Navy explosives.

Pyrotechnics.

15. Smoke boxes and pyrotechnic material shall be stored in approved designated places and shall not be stored in any magazines or near explosives or inflammable materials.

16. In addition, these materials shall be kept dry at all times. They constitute a fire risk that shall be given careful consideration. Smoke boxes have very small amounts of explosives for creating the initial action, but have chemical compositions which due to faulty mechanism may react, resulting in a fierce fire with a great evolution of heat. Rusty containers will quickly result in leaks. Broken paper covers over the smoke holes on the Mark II boxes permit the ingress of moisture, causing deterioration. Pyrotechnics are in the same class as smoke boxes. Both should not be stowed below in any quantities, especially near inflammable materials. It is considered that the best stowage space is above decks.

17. Should a smoke box set off in an inclosed space, personnel may be exposed to asphyxiation by the smoke. When inhaled in the concentrated form as the smoke comes out of the box, it will cause nausea and coughing. The cloud near the apparatus is very dense and may contain phosgene. The Bureau of Medicine and Surgery recommends that the following steps be taken for the relief of personnel subjected to smoke from smoke boxes:

(*a*) Members of rescue parties should wear masks provided with a smoke filter of a kind now made a part of the standard Army gas mask.

(*b*) The individual affected by the smoke should be removed to the fresh air, placed in a recumbent posture, and general measures, such as employed in carbon monoxide poisoning, instituted.

(*c*) First-aid treatment should include artificial respiration, cold applications to the head and neck, applications of heat to the feet and body, and administration of aromatic spirits of ammonia by mouth if the patient is conscious. If unconscious, a medical officer or a hospital corpsman should administer a hypodermic circulatory stimulant to the patient.

(*d*) If an oxygen tank is available this gas should be administered as soon as possible.

18. Other ordnance material can be classed as one of the above, namely: Other explosives.

- Small arms:
  - Ballistite rings.
  - Ballistite cartridges. } For Stokes mortar.
  - Shotgun ammunition.
  - Case ammunition.
  - Bag ammunition.
  - Projectiles L. & F.:
    - Hand grenade without primers.
    - Stokes projectiles.
    - Rifle grenades.
  - War-head storage:
    - Mines, aero bombs, wrecking charges.
    - Trench warfare material without bouchons.
  - Pyrotechnics: Signal material.
  - Detonators: Bouchons for trench warfare material.

Dummy ammunition. **19.** Dummy trench warfare material may be stowed without regard for the above requirements. Dummy loading charges shall not be stowed in magazines or other compartments containing explosives.

Ready service stowage. **20.** Vessels in addition to their regular magazines are equipped with various types of ready service magazines in all cases for case ammunition only. The Bureau of Construction and Repair has cognizance over the design and installation. Anti-aircraft guns on battleships and destroyers, and main battery on destroyers and submarines, have special air-tight boxes arranged for holding the assembled cartridges or tanks. Certain types are arranged to hold the cartridge tank while others are arranged to take the cartridge alone. This ready stowage will be used only when there is likelihood of the guns being used and at other times ammunition will be stowed in the proper containers, in the regular magazines. Ammunition boxes and tanks will be retained on board for this purpose, and care shall be exercised that ammunition is stowed in the proper container. When restowing ammunition in boxes or tanks, or when stowing it in ready service boxes, care will be exercised that the proper nose blocks are used, so that nose fuses will not be damaged.

Location of magazines. **21.** Magazines are specially designed and located for storage of explosives. They must be so located as to minimize the dangers from external explosions, hence are located below the water line, and the protective deck on ships so fitted, and away from the skin of the ship if practicable. Construction, alteration, and repairs to magazines, flooding, sprinkling systems, and ventilating systems, are under cognizance of the Bureau of Construction and Repair. The Bureau of Ordnance has cognizance over suitability and safety of magazines and fittings. The care and upkeep, however, devolves on the commanding officer and the gunnery officer afloat, and the responsibility for seeing that they are used only in an authorized manner consequently is vested in these officers.

Safety precautions. **22.** Due to the methods of manufacture of smokeless powder, it frequently happens that the air becomes laden with ether, and if a spark is introduced an explosion will result provided the mixture has sufficient ether in it. For this reason no naked lights, matches, or flame-producing apparatus is permitted in magazines. Electric wiring is not passed through magazines. When an oxyacetylene flame is to be used adjacent to a magazine, the explosives must be removed. Any similar operation, such as steaming out adjacent oil tanks, heating oil, or using hot rivets, etc., should be considered cause for removing explosives.

Care of magazines. **23.** Magazines shall be kept clean, and no unauthorized articles stowed in them, such as oily rags or painted canvas, due to danger from spontaneous combustion. Care shall be taken that no sand or gravel is tracked in, especially in black powder magazines. Care shall be also taken that there is no danger of a spark originating from striking steel on steel. The air in magazines should be kept pure, and on no account should the circulation be stopped, except under the following condition: In the Tropics it frequently happens that by running blowers in daytime hot air is forced into magazines, increasing their temperature more than would be the normal rise during the day without blowers. In this case, it is advisable to run blowers only at night, filling the magazines with cool air, and allowing it to warm up during the day from conduction from without rather than by passing hot air in. When a magazine is hotter than the outside air for reasons within the ship, portable blowers, windsails, etc., must be used. The small increase in temperature which would result from sealing magazines in an action is not sufficient to have any deleterious effects, but continued storage under these conditions will affect the stability of the powder considerably.

24. The danger of wetting charges due to improper handling of flood valves or leaky valves is always present, and should be guarded against. Powder so wet should be immersed in distilled water and returned to an ammunition depot. **Wet powder.**

25. The life of smokeless powder is greatly affected by the temperature at which it is stored. Furthermore, uniformity of temperature insures more uniform ballistic results. So, if smokeless powder is stored at the temperature which will give it the longest life and retained uniformly at that temperature in a dry state, the best possible conditions will obtain. The fact that powder must be kept at a uniform temperature is seen by the range tables. It has been found by observation that the changes in the stability due to variations in temperatures increase rapidly with increase of temperature. For unstabilized powders the change at 75° F. is very slight, but at 90° F. it is increased appreciably, and at temperatures above 100° F. increases much more rapidly until at 135.5° C. the life of a powder is taken as five hours. With a stabilized powder, the change is much less for corresponding temperatures, such that a stabilized powder at 90° F. has the same or greater life than an unstabilized powder at 75° F. **Temperatures.**

26. The stability and ballistics are greatly affected by moisture. To a certain extent smokeless powder has an affinity for moisture and will absorb it, though rather slowly. If the air in which powder is stored contains a certain amount of moisture, on a decrease of temperature the moisture is condensed and taken up by the powder. If the temperature is raised, moisture is less readily given up by the powder than are its solvents, so that the latter are reduced and some of the moisture retained. With frequent changes of temperature this cycle is repeated, each time changing by a small amount the proportion of solvents and moisture, and in the same measure the ballistic qualities. The importance of air-tight containers is apparent from a consideration of this effect of moisture. **Moisture.**

27. Before the advent of stabilized powder—in fact, with the issue to service of smokeless powders—the necessity for arranging for storage at temperatures less than those met with aboard ship became apparent. In 1899, the question of magazine refrigeration was taken up and an experimental installation placed on board the *Illinois*. It consists of a dense air machine with brine pipes for circulating the brine through the magazines, which were not insulated. The system was not a success, and was not installed on any other ships at that time. **Refrigeration.**

Later installations. **28.** In 1908, the question was again taken up and another test installation placed on the old *Iowa*, consisting of a carbon dioxide machine with a cooler box outside the magazines spaces through which air was forced, thence into the magazines and back to the cooler box in a closed system. Later installations on the *Delaware* and *North Dakota* were similar to that on the *Iowa*, except steam-driven dense air machines were used and the air could be drawn by ventilator fans from the cooler box or from the outside air. However, these installations were not successful, and the one on the *North Dakota* was changed to an ethyl chloride machine with brine pipes in the magazines, producing thereby more satisfactory results.

29. Later ships from the *Florida* to the *Wyoming*, inclusive, were fitted out with dense air machines and cooled air ventilation similar to the *Delaware* type, except that thicker insulation was provided. The *New York* has a CO_2 system with brine pipes and the *Texas* the cooled air ventilation system. Later ships are not fitted out with magazine cooling systems.

Requirements. **30.** In considering the installation of magazine cooling the following factors must be considered:

(*a*) Necessity for.
(*b*) Performance.
(*c*) Reliability.
(*d*) Cost of installation and upkeep.
(*e*) Space and weight involved.

Necessity for cooling. **31.** Variations in temperature occur when ships enter and leave the Tropics or from summer to winter, or from circumstances within the ship, and may be of three kinds: (*a*) Variations in temperature due to external changes, (*b*) variations in different parts of the same ship, (*c*) variations in different parts of the same magazine. From a long series of observations, these differences have been found to amount to from 40° to 60° F. under (*a*), from 12° to 16° F. maximum under (*b*), and about 6°F. maximum under (*c*). With unstablized powders where the stability life was affected by changes over 75° F., the necessity for a magazine cooling system was evident as a change like under (*a*) would be very damaging. Conditions could be improved under (*b*), as some degree of control is permitted by a cooling system, but a remedy for the condition under (*c*) is not so easily found. With stabilized powders, however, together with improved location of magazines, adequate heat insulation, and care in locating ventilator intakes and exhausts, the ill effects from changes in temperatures have been so greatly reduced that the necessity for magazine cooling installations are no longer apparent.

32. To be effective a cooling system must operate continuously, as with either brine system or closed ventilating system, without the aid of the cooling installation the temperatures will mount up faster than in magazines designed for cooling by outside air by means of blowers. To guard against a shutdown, duplicate installations are required. With the brine systems, drip pans, coils, etc., are required, but with all precautions the air is heavily laden with moisture. This is true to a less degree with the cooled air system, but to give the best results the air should be dried before entering the magazines.

33. Even with duplicate sets, breakdowns will occur with this type of installation, with resulting greater effect than when a unit in the ventilating systems breaks down.

34. The cost of installation is very great, and the cost of upkeep is also very great, far outweighing any slight advantage over the later systems of magazine ventilation. The space and weight involved is also a great loss when the advantages are considered. From a survey of these conditions, it has been decided that no further installations will be made except on ammunition ships. **Cost.**

PLATE XXV.

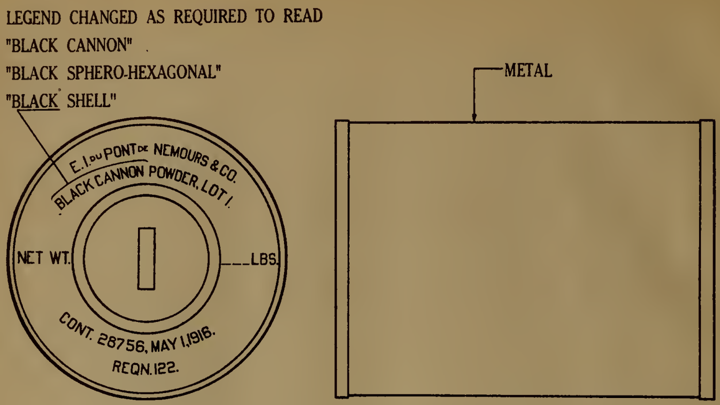

LEGEND CHANGED AS REQUIRED TO READ
"BLACK CANNON"
"BLACK SPHERO-HEXAGONAL"
"BLACK SHELL"
E. I. DU PONT DE NEMOURS & CO.
BLACK CANNON POWDER, LOT 1.
NET WT. ___LBS.
CONT. 28756, MAY 1, 1916.
REQN. 122.
METAL

FIG. 1. BLACK POWDER DRUM

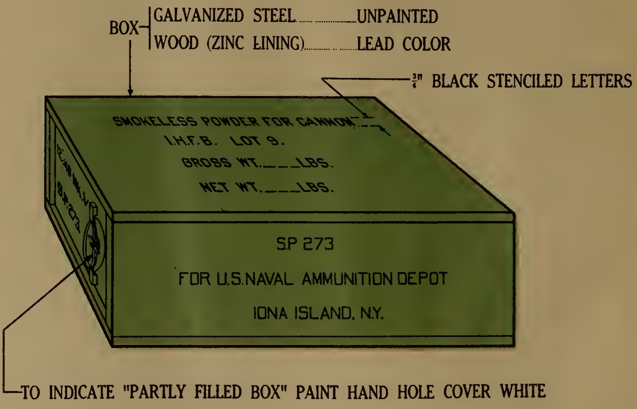

BOX
GALVANIZED STEEL .... UNPAINTED
WOOD (ZINC LINING) .... LEAD COLOR
3/4" BLACK STENCILED LETTERS
SMOKELESS POWDER FOR CANNON
I.H.F.B. LOT 9.
GROSS WT.___LBS.
NET WT.___LBS.
S.P 273
FOR U.S. NAVAL AMMUNITION DEPOT
IONA ISLAND, N.Y.
TO INDICATE "PARTLY FILLED BOX" PAINT HAND HOLE COVER WHITE

FIG. 2. SMOKELESS POWDER PACKING BOX

Powder Containers.

Chapter XVIII.

MARKING OF AMMUNITION.

General instructions.

1. The following instructions shall govern the marking and painting of containers for explosives and of ammunition issued to the United States naval service.

2. These instructions are to supersede all previous ones on the same subject. In relation to this subject, attention is invited to the following publications:

(*a*) Ordnance Pamphlet No. 368, part 1, "Ammunition Instructions for Marking and Painting for the United States Naval Service, Projectiles as Furnished by Manufacturers."

(*b*) "United States Naval Ordnance Pamphlet No. 4.

(*c*) The Interstate Commerce Commission Regulations for the "Transportation of Explosives."

3. Particular attention is also invited to the following provision of the Naval Instruction, article 2805:

"*Since the correctness of reports and records depends upon it, care must be taken not to obliterate the identification marks on ammunition or to interchange it in incorrectly marked containers.*"

Strict compliance with this regulation is enjoined, as the safety of ships and personnel is dependent on the accuracy of ammunition records.

4. Target projectiles which have been painted different colors on board ship will have all paint removed before turning in to ammunition depots.

Smokeless-powder containers.

5. Smokeless powder shall be packed at the factory in standard air-tight smokeless powder packing boxes made of galvanized steel or of wood with zinc lining. If of wood, the boxes shall be painted lead color with a suitable paint. "cold water" paint conforming to Specification 52P1b is satisfactory for the purpose. If of galvanized steel, the boxes shall be unpainted. These boxes shall be plainly marked with black block letters, three-fourths inch high, as follows:

On end containing handhole:

Caliber of gun for which intended (also mark of gun if required).
Index number of powder.

On top of box:

"Smokeless powder for cannon."
Manufacturer's designation of lot. (This shows the name of the factory.)
Gross weight ———; net weight, ———.

On right side:
Index number.
Shipping directions.

NOTE.—If new powder is being shipped for proof of lot, mark "Firing sample for proof" and omit index number on all legends.

End containing handhole:

12/″45 Mk. V
S. P. 273.

Top of box:

SMOKELESS POWDER FOR CANNON.
I. H. F. B. LOT 9.
Gross Wt. ...... Net Wt. ......

Right side:

S. P. 273.
FOR U. S. NAVAL AMMUNITION DEPOT,
Iona Island, N. Y.

6. The arrangement of the legends in this manner allows the top of the box to be completely marked at the time of packing and the other marking done upon the receipt of order for shipment, which also assigns the index. The letters "S. P." will indicate that the number following them is the index number of the powder. The prefix to the index number, S. P., R., W., D., B., and X., or combinations of these letters, indicates the composition of the material and is a part of the index number. All stenciling of boxes should be done with eveness and uniformity and care taken not to blur the lettering. The information formerly put on the boxes relating to powder charge, ignition, date of proof, etc., has been omitted, as it can be obtained more satisfactorily from stock cards, and large stenciling and less lettering improves the clearness of the work.

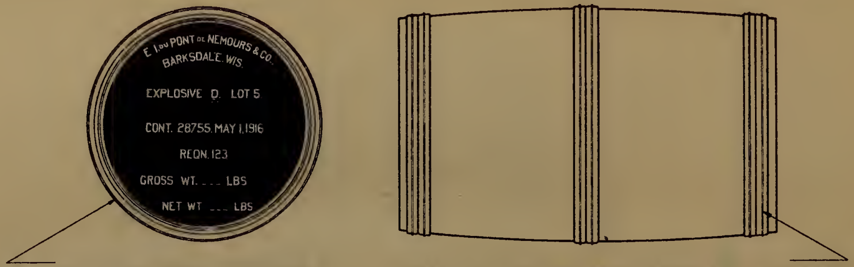
7. In making shipments of smokeless powder in bulk, a partly filled box will have the handhole cover painted white.

8. Shipments of smokeless powder from naval ammunition depots to Indianhead shall be marked as specified in United States Naval Ordnance Manual, Part V, article 57.

Black powder containers.

9. Black powder will be supplied to ammunition depots in metal kegs or drums having interior bags and conforming to the Interstate Commerce Commission shipping container specifications. The drums will be marked to show the manufacturer's data, for example, as follows:

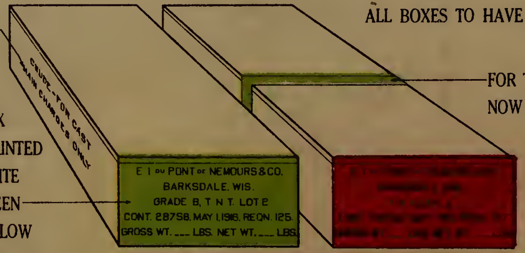
E. I. duPont de Nemours & Co.,
Black Cannon Powder, Lot 1.
Net ——— Lbs.
Cont. 28756, May 1, 1916, Reqn. 122.



KEG HEAD PAINTED BLACK. USE WHITE STENCILED LETTERS.

WOODEN KEG WITH WOODEN HOOPS, COPPER WIRE BOUND. KEG PAINTED NON-ACID BLACK.

FIG. 1. EXPLOSIVE D. KEG.


CRUDE—FOR CAST MAIN CHARGES ONLY
E. I. du PONT de NEMOURS & CO.
BARKSDALE. WIS.
GRADE B, T. N. T. LOT 2
CONT. 28758. MAY 1, 1916. REQN. 125.
GROSS WT. ___ LBS. NET WT. ___ LBS.

FOR GRADE B, T.N.T. PACKING BOX ONLY.

ALL BOXES TO HAVE BLACK STENCILED LETTERS.

FOR T.N.X. PACKING BOXES NOW IN SERVICE ONLY.

FOR	BOX END PAINTED
GRADE A, T.N.T.	WHITE
GRADE B, T.N.T.	GREEN
T.N.A.	YELLOW
T.N.X.	RED

FIG. 2. HIGH EXPLOSIVE BOXES.

Explosive Containers.

WILLIAMS WEBB CO INC WASH D C

10. Index numbers will not be assigned to lots of black powder.

11. Containers for black powder should always indicate the kind of powder, such as—

(*a*) Cannon.
(*b*) Shell.
(*c*) Sphero-hexagonal (torpedo impulse).

High explosives.

12. High explosives (Plate 26) will be supplied the ammunition depots in containers conforming to the Interstate Commerce Commission regulations, explosive "D," in wooden kegs with copper wire-bound wooden hoops; other high explosives in wooden boxes. These containers must have interior paper linings sealed on packing. The containers are not to be used again for the purpose of making shipments, but should be destroyed. They are marked to show the material, manufacturer, contract number and date, requisition number, lot number, gross and net weight, thus:

E. I. duPont de Nemours & Co., Barksdale, Wis.
Grade "A" T. N. T., Lot 1.
Cont. 28757, May 1, 1916, Reqn. 123.
Gross ——— Lbs. Net ——— Lbs.

13. Explosive "D" containers will be painted a nonacid black with white stenciling.

14. The boxes for other high explosives will have the ends painted a solid color with black stenciling, as follows:

Grade A, T. N. T.	White.
Grade B, T. N. T.	Green.
T. N. A.	Yellow.
T. N. X.	Red.

In addition, grade "B," T. N .T. containers will have stenciled on the side the following precautionary note:

"Crude—for cast main charges only."

This marking is very important, as grade "B," T.N.T. is intended only for use in cast main charges of torpedo war heads, mines, depth charges, and bombs, and never for use as a burster charge of a projectile or burster charge either in the cast or granular form.

NOTE.—T. N. X. containers now have green bands painted around middle of container. These need not be changed, but will assist in identifying T. N. X. containers with red ends.

15. Poison gas is shipped in containers ready for loading direct into projectiles. Special markings on each container, such as a black cross or a green cross or other geometrical figure, will denote the kind of material. These markings will be known by special arrangements between the manufacturer, the bureau, and the ammunition depots. Gas containers are to be packed in strong air-tight barrels, with heads paraffined, suitably marked with a broad red band with the number of containers and kind and color of geometrical figure, name of manufacturer, contract number, date of loading, gross and net weight of each container.

Marking of ammunition for ships: bag gun charges.

16. All bag gun charges (Plate 27) put up in silk powder bags shall be marked with stencil on each bag in black letters, three-fourths inch high, parallel to and on the opposite side from the lacing, as follows:

Caliber of gun (and mark if required).
Index number of powder.
Weight of smokeless powder contained in bag.
Proportion bag bears to full (or experimental) charge.
Initial velocity.
Initials of inspector.

The letters "F. C." shall be used on the legend as an abbreviation of the words "full charge." If the bag constitutes the full charge, it is marked "F. C."; but if only part of the full charge, it is marked "$\frac{1}{4}$ F. C.," "$\frac{1}{2}$ F. C.," etc., as the case may be. Reduced charges are no longer issued to service, except for target or experimental firing, in which case the marking of the bag (and also of the identification tag and powder tank) shall read "Exp. Chg.," "$\frac{1}{2}$ Exp. Chg.," etc., as the case may be.

17. The dyed iginition ends of bag gunpowder bags shall be marked in black letters, three-fourths inch high, as follows:

Ignition ------grams.

18. No paint containing oil shall be used in marking bags and care must be taken not to blur the stenciling.

Powder identification tags.

19. Identification tags are to be used with all smokeless powder charges. These tags contain the following data:

Caliber of gun.
Index of powder.
Weight of powder contained and proportion of full or experimental charge.
Initial velocity.
Weight of ignition (if ignition is contained in primer, state "primer ignition").
Fahrenheit readings of wet and dry bulb thermometers. (See United States Naval Ordnance Manual, Pt. V, art. 202.)
Ammunition depot (where prepared).
Date.
Initials of weigher.
Initials of checker.
Initials of gauger.
Initials of gunner in charge.
Initials of inspector in charge.

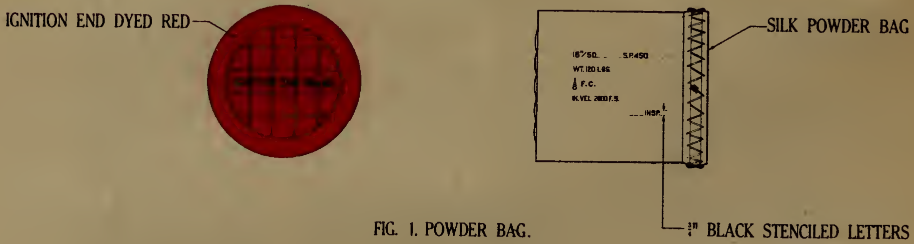


FIG. 1. POWDER BAG.

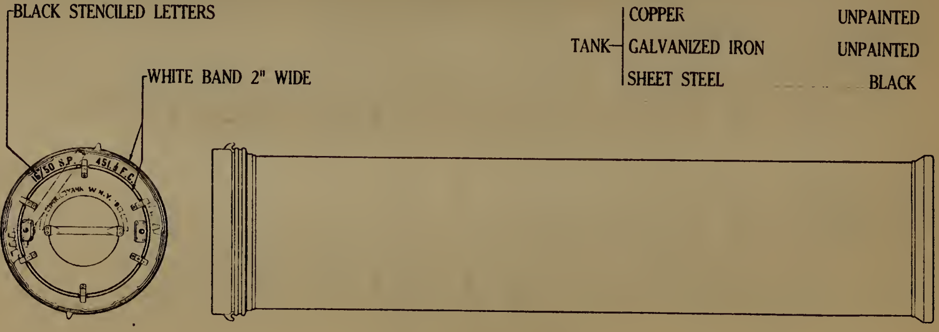


FIG. 2. POWDER TANK.

Bag Gur Charge Containers.

20. The identification tags are made of cloth and should be of the smallest size practicable to contain all the necessary information. With powder bags, the tags are placed under the lacing of the bags before the final tautening of the lacing and are in addition to the data stenciled on the bags. With case ammunition, the tags are placed in the cartridge cases on top of the powder under the wads.

21. In addition to the identification tag, case ammunition should have the index number of the powder used stenciled on the head of each cartridge case, using a thin mixture of shellac and lampblack.

22. Powder tanks are copper, galvanized iron, or sheet steel. The first two will be marked as in paragraph 2. The last will be parkerized or coated on the outside with black paint, and painted as in paragraph 2. **Powder tanks.**

23. Each powder tank containing all or part of a full or experimental charge shall be marked with a circular band of white paint, 2 inches wide, if practicable, around the edge of the cover and have painted upon this band in black letters the caliber of the gun, index of powder, and proportion of full or experimental charge in the tank.

24. Each powder tank shall in addition have wired to it a cloth tag giving the information shown in the powder identification tag attached to the powder bag.

25. Full instructions regarding the marking and painting of projectiles as supplied by manufacturers are given in Ordnance Pamphlet No. 368, Part I, April 1920 (Revised). **Projectiles (empty).**

Cavities of projectiles are painted as prescribed in Ordnance Pamphlet No. 368, Part I, paragraphs 17–21, and in Ordnance Pamphlet No. 4. **Cavity paint.**

As issued to ships, the ogivals of projectiles for a distance of 1 caliber from the point toward the bourrelet are painted with distinctive colors to indicate the *kind of projectile filler;* the remainder of the exteriors (except the bourrelet, band, and base) are painted with distinctive colors to indicate the *type of projectile.* **Exterior paint.**

26. Bourrelets and bases of all projectiles and base plugs shall not be painted, but shall be coated with vaseline to protect the surface from rusting. Rotating bands must not be painted.

27. For projectiles used with cartridge cases, the exteriors from rotating band to base shall not be painted, but shall be coated with vaseline.

28. The standard colors to be used in painting projectiles are shown in Ordnance Pamphlet No. 368, Part I, Plate I. The surface of the projectiles should be carefully cleaned before painting and all grease or oil removed; paint should in all cases be applied evenly and the thickness of the coat limited to the least amount required to protect the surface and produce the desired color. Exterior paint shall conform to Standard Navy specifications for paints.

29. The distinctive colors mentioned in paragraph 25, exterior paint, above for indicating the type of projectile are as follows:

Armor-piercing projectiles	**Black.**
Common projectiles	**Slate color.**
Class B projectiles	**Dark green.**
Shrapnel	**White.**
Target projectiles	**Unpainted.**
Illuminating projectiles	**Light blue with white star.**
Antiaircraft	**Unpainted.**

30. One-pounder antiaircraft projectiles are issued to service unpainted, but lightly coated with vaseline.

Projectiles (loaded and fused).

31. The distinctive colors mentioned in paragraph 25, exterior paint above for indicating the kind of projectile filler, are as follows:

Black powder	**Slate color.**
Explosive "D"	**Yellow.**
T. N. T	**Dark green.**
Blind loaded	**Unpainted.**
Gas	**Red (with geometrical figure).**

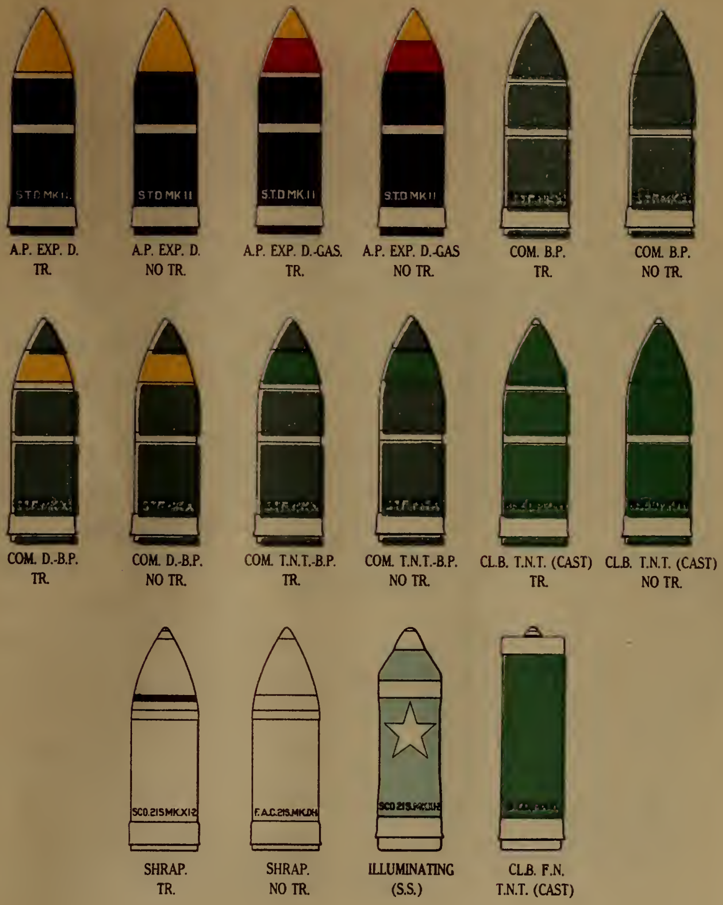
(The geometrical figure will be of a size which can be inscribed in a circle of one-half the diameter of the projectile and of such a shape and color as will designate the kind of gas-producing material. The meaning of the geometrical figures and colors will be known by the manufacture, bureau, inspector, and ammunition depots only.)

32. The burster charge of projectiles loaded with T. N. T.–B. P. shell filler shall be indicated by painting the ogival dark green for one-half caliber distance from the point toward the bourrelet followed by a band of slate color one-half caliber wide. Similarly the burster charge of projectiles loaded with the D–B P shell filler shall be indicated by painting the ogival yellow for one-half caliber distance from the point toward the bourrelet followed by a band of slate color one-half caliber wide. (See United States Naval Ordnance Manual, Pt. V, arts. 221–223.) Projectiles gas loaded will have a red band below the one indicating the explosive in a similar way, and if a mixed projectile filler is used, the distance will be divided into thirds with yellow or green at top, slate next, and red next.

33. Projectiles fitted with night tracers or tracer fuses shall have a white band 1 inch wide painted around the ogival of the projectile just below the color indicating the bursting charge. If any projectile in which the color indicating the bursting charge may extend to the bourrelet, the white tracer band shall be painted on the ogival next to the bourrelet. For shrapnel fitted with tracers, the tracer band shall be black.

34. Nose fuses shall never be painted, except that the tips of time fuses shall be painted red to distinguish them from time-percussion fuses.

35. The paint indicating the bursting charge of projectiles fitted with nose fuses shall begin immediately below the fuse and shall extend toward the bourrelet,



A.P. EXP. D.
TR.

A.P. EXP. D.
NO TR.

A.P. EXP. D.-GAS.
TR.

A.P. EXP. D.-GAS
NO TR.

COM. B.P.
TR.

COM. B.P.
NO TR.

COM. D.-B.P.
TR.

COM. D.-B.P.
NO TR.

COM. T.N.T.-B.P.
TR.

COM. T.N.T.-B.P.
NO TR.

CL.B. T.N.T. (CAST)
TR.

CL.B. T.N.T. (CAST)
NO TR.

SHRAP.
TR.

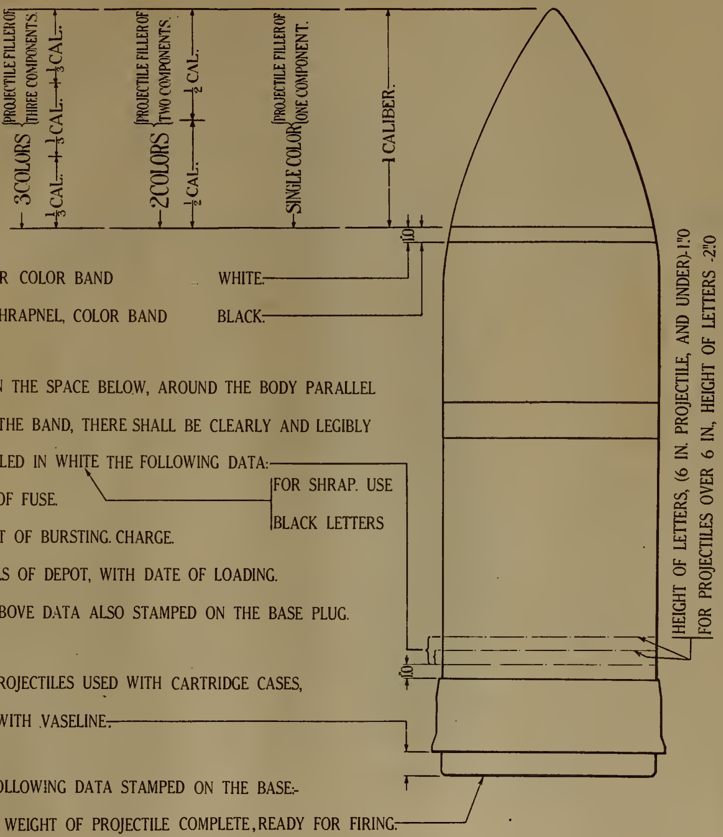
SHRAP.
NO TR.

ILLUMINATING
(S.S.)

CL.B. F.N.
T.N.T. (CAST)

WILLIAMS-WEBB CO INC WASH D C

Projectiles, Loaded and Fused.


3 COLORS {PROJECTILE FILLER OF THREE COMPONENTS.
1/3 CAL.
1/3 CAL.
1/3 CAL.
2 COLORS {PROJECTILE FILLER OF TWO COMPONENTS.
1/2 CAL.
1/2 CAL.
SINGLE COLOR {PROJECTILE FILLER OF ONE COMPONENT.
1 CALIBER.
1.0
1.0
HEIGHT OF LETTERS, (6 IN. PROJECTILE, AND UNDER)-1".0
FOR PROJECTILES OVER 6 IN., HEIGHT OF LETTERS -2".0

TRACER COLOR BAND WHITE.

FOR SHRAPNEL, COLOR BAND BLACK.

WITHIN THE SPACE BELOW, AROUND THE BODY PARALLEL WITH THE BAND, THERE SHALL BE CLEARLY AND LEGIBLY STENCILED IN WHITE THE FOLLOWING DATA:

TYPE OF FUSE.

WEIGHT OF BURSTING CHARGE.

INITIALS OF DEPOT, WITH DATE OF LOADING.

THE ABOVE DATA ALSO STAMPED ON THE BASE PLUG.

FOR SHRAP. USE BLACK LETTERS

FOR PROJECTILES USED WITH CARTRIDGE CASES, COAT WITH VASELINE.

THE FOLLOWING DATA STAMPED ON THE BASE:-

TOTAL WEIGHT OF PROJECTILE COMPLETE, READY FOR FIRING.

Projectile Data.

but in no case shall the bourrelet be painted. If the form of any projectile is such that a caliber distance from the point of its nose fuse toward the bourrelet extends beyond the bourrelet, the paint indicating the bursting charge shall stop at the bourrelet.

36. When projectiles are loaded, they shall have stamped on their base plugs (or on copper base cover of old style projectiles) and clearly and legibly stenciled around the body parallel to the band, the following: Type of fuse, weight of bursting charge, and initials of depot with date of loading. Stenciling on projectiles to be in white letters 1 inch high (where practicable) for all sizes below and including 6 inches, 2 inches high for all above 6 inches. In case of shrapnel, letters will be black.

37. The total weight of the projectile complete ready for firing will be stamped on the base for projectiles 3 inches and larger after the word "COMPL" stamped on base by manufacturer.

Separate case ammunition boxes.

38. Boxes containing the cartridge case of 6-inch 50-caliber (Eng.), 6-inch 40–45 caliber, and 4.7-inch (Eng.), separate case ammunition (Plate 30), shall be painted light green and shall be plainly marked with black letters, three-fourths inch high, as follows:

(*a*) On one of the sides adjacent to removable cover—
  Caliber of gun.
  Index of powder.
  Weight of charge.
  Initial velocity.
  Mark, manufacturer, and date of primer.
  Name of depot at which charge was put up.
  Date.
  Initials of gunner in charge.
  Initials of inspector in charge.

(*b*) On each end—
  Caliber of gun.
  Index of powder.

When these boxes contain ammunition issued especially for target practice, they shall be painted red.

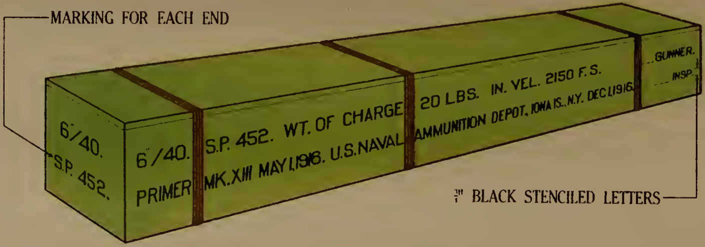
39. Boxes containing fixed ammunition (5-inch 40-caliber and below) shall be painted to indicate the character of the projectile as follows:

Armor-piercing projectiles	**Black.**
Common projectiles	**Slate color.**
Class B projectiles (see Ord. Pamphlet 368)	**Dark green.**
Shrapnel	**White.**
Target (blind) ammunition	**Red.**
Illuminating	**Light blue.**

SEPARATE CASE AMMUNITION, 6"/50, 6"/45, 6"/40, 4".7 (ENG).

FOR SERVICE AMMUNITION, BOX PAINTED............LIGHT GREEN

FOR TARGET AMMUNITION, BOX PAINTED........................RED


6"/40.
S.P. 452.
6"/40.
PRIMER
S.P. 452. WT. OF CHARGE
MK. XIII MAY 1, 1916. U.S. NAVAL
20 LBS. IN. VEL. 2150 F.S.
AMMUNITION DEPOT, IOWA IS., N.Y. DEC 1, 1916.
GUNNER.
INSP.

MARKING FOR EACH END

3/4" BLACK STENCILED LETTERS

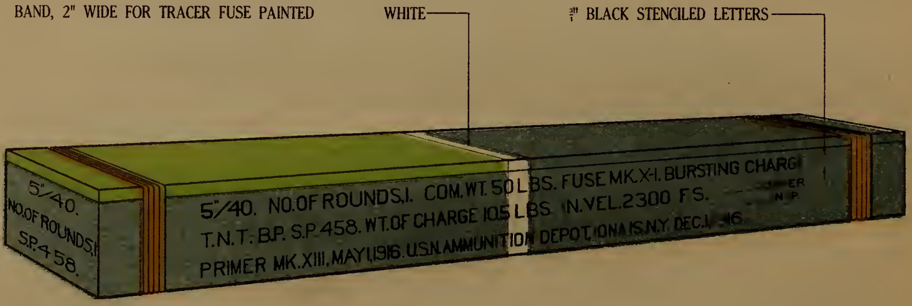
Separate Case Ammunition Box.

BOX PAINTED .... SLATE

½ OF COVER PAINTED .... SLATE

BALANCE OF COVER PAINTED .... GREEN

BAND, 2" WIDE FOR TRACER FUSE PAINTED WHITE


WHITE
¾" BLACK STENCILED LETTERS
5"/40. NO.OF ROUNDS,I. COM.WT. 50 LBS. FUSE MK.X-I. BURSTING CHARG
T.N.T.-B.P. S.P. 458. WT.OF CHARGE 10.5 LBS. N.VEL. 2300 F.S.
PRIMER MK.XIII, MAY 1, 1916. U.S.N. AMMUNITION DEPOT, IONA IS. N.Y. DEC.1, 16.
ER
N.P.
5"/40.
NO.OF ROUNDS,I
S.P. 458.

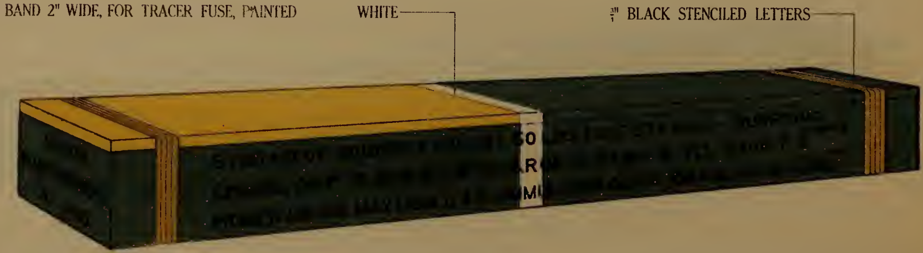
COMMON PROJECTILE. T.N.T.-B.P. BURSTER CHARGE.

Fixed Case Ammunition Box.

BOX PAINTED SLATE

¼ OF COVER PAINTED SLATE

BALANCE OF COVER PAINTED YELLOW

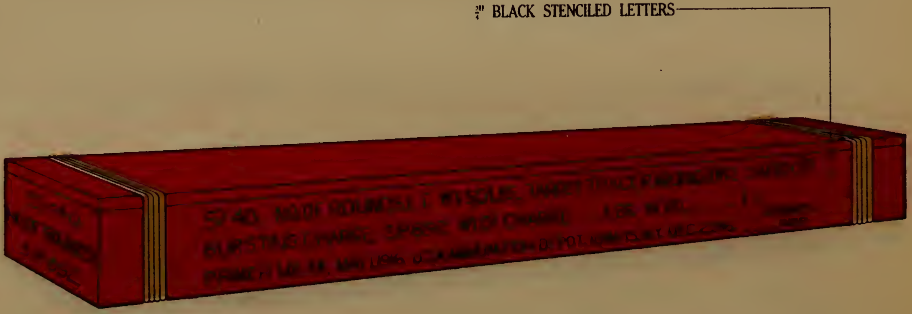

BAND 2" WIDE, FOR TRACER FUSE, PAINTED WHITE
¾" BLACK STENCILED LETTERS

COMMON PROJECTILE, D-B.P. BURSTER CHARGE.

Fixed Case Ammunition Box

BOX PAINTED ---------- RED

COVER PAINTED ---------- RED



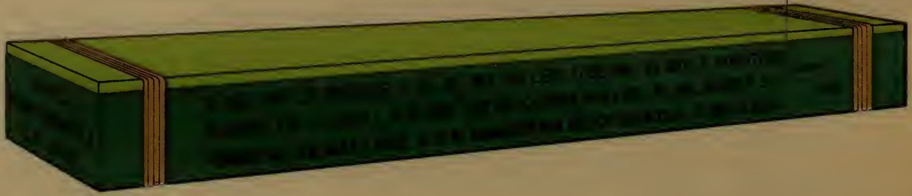
TARGET PROJECTILE.

Fixed Case Ammunition Box.

PLATE XXXIV.

BOX PAINTED .... DARK GREEN

COVER PAINTED .... LIGHT GREEN



¾" BLACK STENCILED LETTERS

CLASS B PROJECTILE, T.N.T. BURSTER CHARGE.

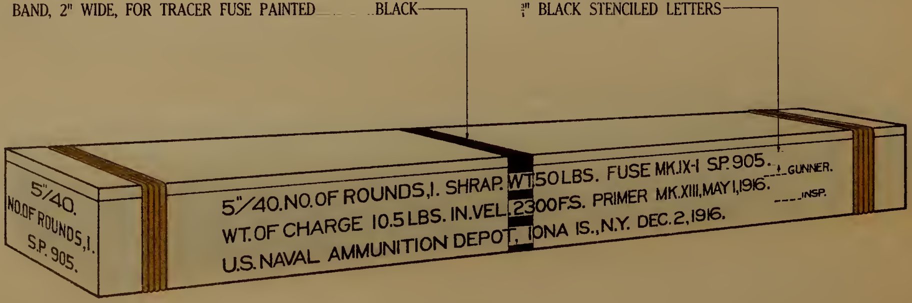
Fixed Case Ammunition Box.

BOX PAINTED . . . . WHITE

COVER PAINTED . . . . WHITE

BAND, 2" WIDE, FOR TRACER FUSE PAINTED . . . BLACK

¾" BLACK STENCILED LETTERS


5"/40.
NO.OF ROUNDS,1.
S.P. 905.
5"/40.NO.OF ROUNDS,1. SHRAP. WT.50 LBS. FUSE MK.IX-1 S.P. 905.
WT. OF CHARGE 10.5 LBS. IN.VEL. 2300 F.S. PRIMER MK.XIII, MAY 1, 1916.
U.S. NAVAL AMMUNITION DEPOT, IONA IS., N.Y. DEC. 2, 1916.
GUNNER.
INSP.

SHRAPNEL.

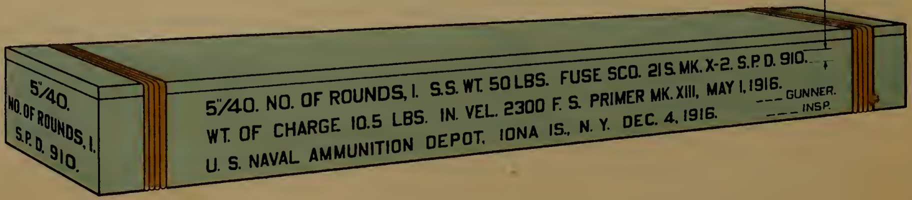
Fixed Case Ammunition Box.

PLATE XXXVI.

BOX PAINTED — LIGHT BLUE

COVER PAINTED — LIGHT BLUE

¾" BLACK STENCILED LETTERS


5"/40.
NO. OF ROUNDS, I.
S.P.D. 910.
5"/40. NO. OF ROUNDS, I. S.S. WT. 50 LBS. FUSE SCO. 21 S. MK. X-2. S.P.D. 910.
WT. OF CHARGE 10.5 LBS. IN. VEL. 2300 F. S. PRIMER MK. XIII, MAY 1, 1916.
U. S. NAVAL AMMUNITION DEPOT. IONA IS., N. Y. DEC. 4, 1916.
--- GUNNER.
--- INSP.

ILLUMINATING PROJECTILE.

Fixed Case Ammunition Box.

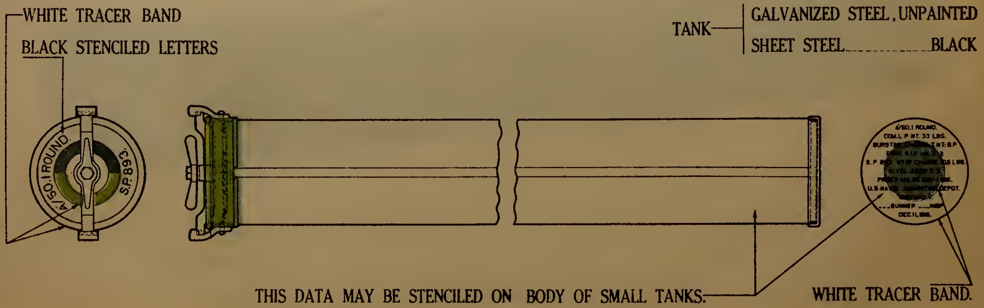
PLATE XXXVII.

COVER MARKINGS.

FOR BURSTING CHARGE	COVER PAINTED
B.P.	SLATE
EXP.D.	YELLOW
T.N.T.	GREEN
T.N.T.-B.P.	½ GREEN ½ SLATE
BLIND LOADED	RED

CARTRIDGE TANK MARKINGS.

FOR PROJ.	BOTTOM PAINTED	LETTERS STENCILED
COM.	SLATE	BLACK
CL. B.	DARK GREEN	BLACK
SHRAP.	WHITE	BLACK
TARGET (BLIND)	RED	BLACK
S. S.	LIGHT BLUE	BLACK


WHITE TRACER BAND
BLACK STENCILED LETTERS
4/50.1 ROUND.
S.P.893.
TANK
GALVANIZED STEEL, UNPAINTED
SHEET STEEL .... BLACK
4/50.1 ROUND.
COM.L P WT. 33 LBS.
U.S NAVAL AMMUNITION DEPOT.
DEC 11,
THIS DATA MAY BE STENCILED ON BODY OF SMALL TANKS.
WHITE TRACER BAND.

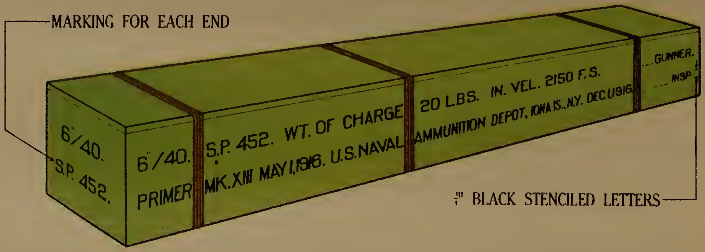
Cartridge Tank.

PLATE XXX.

SEPARATE CASE AMMUNITION, 6"/50. 6"/45, 6"/40, 4".7 (ENG).

FOR SERVICE AMMUNITION, BOX PAINTED............LIGHT GREEN

FOR TARGET AMMUNITION, BOX PAINTED........................RED


MARKING FOR EACH END
6"/40.
S.P. 452.
6"/40.
PRIMER
S.P. 452. WT. OF CHARGE
MK. XIII MAY 1, 1916. U.S. NAVAL
20 LBS. IN. VEL. 2150 F.S.
AMMUNITION DEPOT, IONA IS., N.Y. DEC 1, 1916.
GUNNER.
INSP.
$\frac{3}{4}$" BLACK STENCILED LETTERS

Separate Case Ammunition Box.

WILLIAMS WEBB CO INC WASH D C

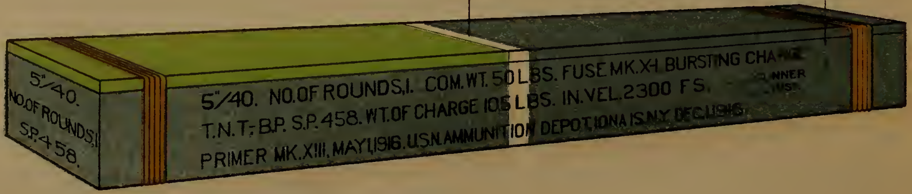
BOX PAINTED .... SLATE

$\frac{1}{2}$ OF COVER PAINTED .... SLATE

BALANCE OF COVER PAINTED .... GREEN

BAND, 2" WIDE FOR TRACER FUSE PAINTED WHITE

$\frac{3}{4}$" BLACK STENCILED LETTERS


5"/40.
NO.OF ROUNDS.I.
S.P.458.
5"/40. NO.OF ROUNDS.I. COM.WT. 50 LBS. FUSE MK.X-I. BURSTING CHARGE
T.N.T.-B.P. S.P.458. WT.OF CHARGE 10.5 LBS. IN.VEL.2300 F.S.
PRIMER MK.XIII, MAY 1,1916. U.S.N.AMMUNITION DEPOT, IONA IS.N.Y. DEC.1,1916.

COMMON PROJECTILE. T.N.T.-B.P. BURSTER CHARGE.

Fixed Case Ammunition Box.

PLATE XXXII.

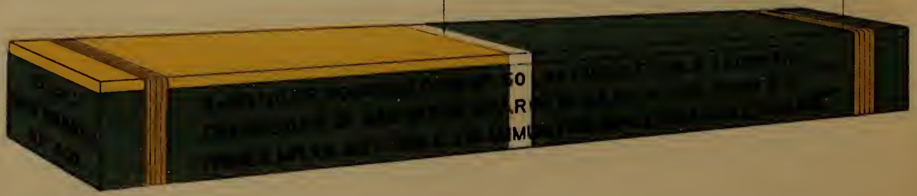
BOX PAINTED . . . . SLATE

⅓ OF COVER PAINTED . . . SLATE

BALANCE OF COVER PAINTED . YELLOW

BAND 2" WIDE, FOR TRACER FUSE, PAINTED WHITE

¾" BLACK STENCILED LETTERS



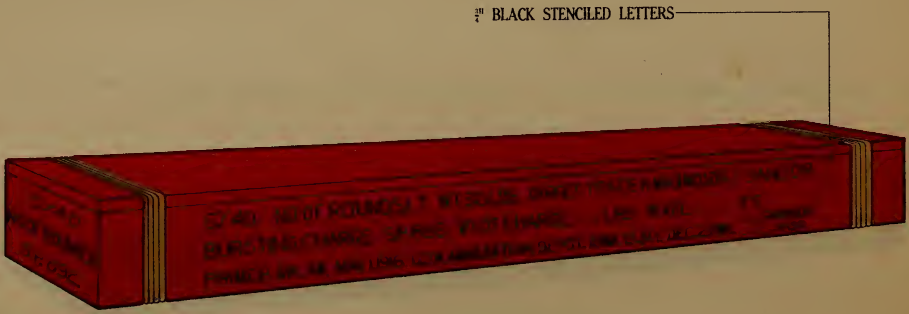
COMMON PROJECTILE, D-B.P. BURSTER CHARGE.

WILLIAMS WEBB CO INC. WASH D C

Fixed Case Ammunition Box.

BOX PAINTED .... RED

COVER PAINTED .... RED



TARGET PROJECTILE.

Fixed Case Ammunition Box.

WILLIAMS-WEBB CO. INC. WASH D C

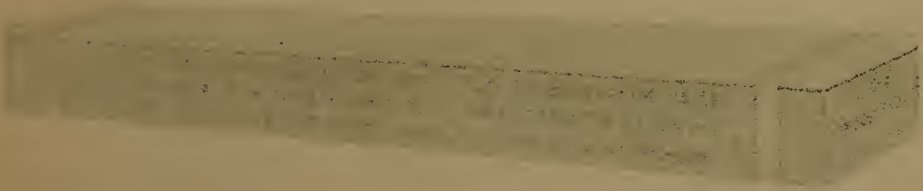
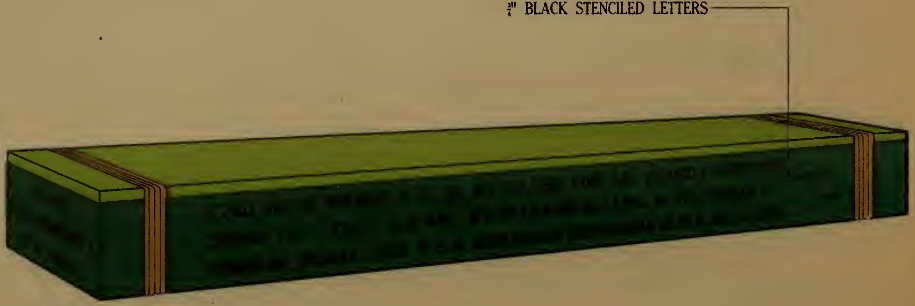


PLATE XXXIV.


BOX PAINTED .... DARK GREEN
COVER PAINTED .... LIGHT GREEN
¾" BLACK STENCILED LETTERS

CLASS B PROJECTILE, T.N.T. BURSTER CHARGE.

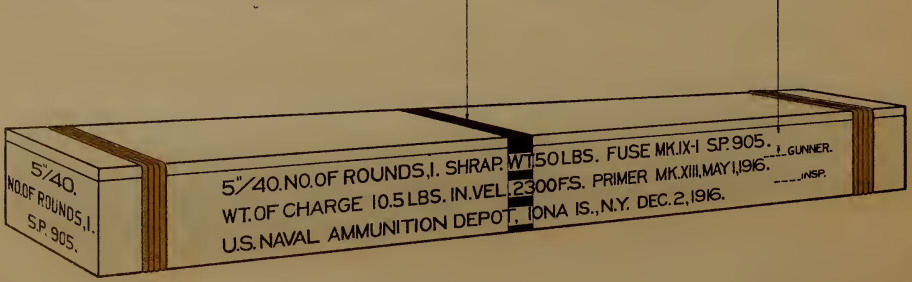
Fixed Case Ammunition Box.

BOX PAINTED WHITE

COVER PAINTED WHITE

BAND, 2" WIDE, FOR TRACER FUSE PAINTED BLACK

¾" BLACK STENCILED LETTERS


5"/40.
NO. OF ROUNDS, I.
S.P. 905.
5"/40. NO. OF ROUNDS, I. SHRAP. WT. 50 LBS. FUSE MK. IX-I S.P. 905. I GUNNER.
WT. OF CHARGE 10.5 LBS. IN. VEL. 2300 F.S. PRIMER MK. XIII, MAY 1, 1916. INSP.
U.S. NAVAL AMMUNITION DEPOT, IONA IS., N.Y. DEC. 2, 1916.

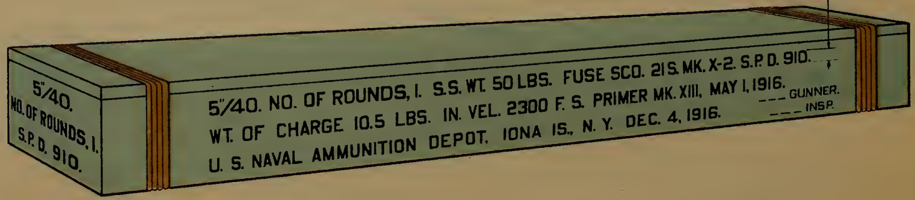
SHRAPNEL.

Fixed Case Ammunition Box.

BOX PAINTED - - - - - - LIGHT BLUE

COVER PAINTED LIGHT BLUE

$\frac{3}{4}$" BLACK STENCILED LETTERS


5"/40.
NO. OF ROUNDS, I.
S.P.D. 910.
5"/40. NO. OF ROUNDS, I. S.S. WT. 50 LBS. FUSE SCD. 21 S. MK. X-2. S.P. D. 910.
WT. OF CHARGE 10.5 LBS. IN. VEL. 2300 F. S. PRIMER MK. XIII, MAY 1, 1916.
U. S. NAVAL AMMUNITION DEPOT. IONA IS., N. Y. DEC. 4, 1916.
--- GUNNER.
--- INSP.

ILLUMINATING PROJECTILE.

Fixed Case Ammunition Box.

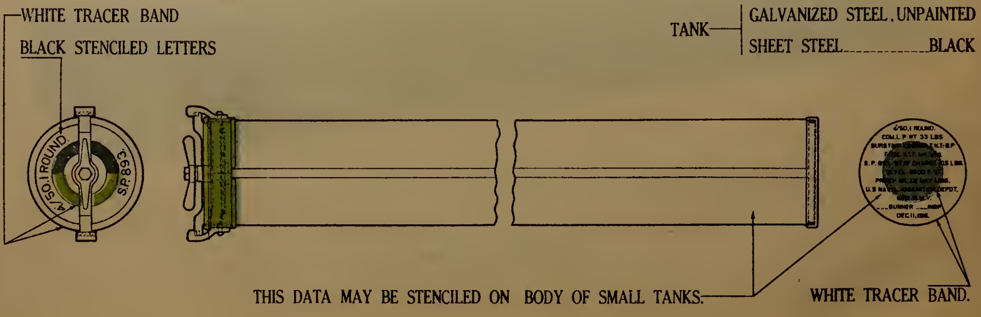
PLATE XXXVII.

COVER MARKINGS.

FOR BURSTING CHARGE	COVER PAINTED
B.P.	SLATE
EXP.D.	YELLOW
T.N.T.	GREEN
T.N.T.-B.P.	½ GREEN ½ SLATE
BLIND LOADED	RED

CARTRIDGE TANK MARKINGS.

FOR PROJ.	BOTTOM PAINTED	LETTERS STENCILED
COM.	SLATE	BLACK
CL. B.	DARK GREEN	BLACK
SHRAP.	WHITE	BLACK
TARGET (BLIND)	RED	BLACK
S. S.	LIGHT BLUE	BLACK



Cartridge Tank.

(*a*) The top and edges of the *covers* of boxes containing fixed ammunition shall be painted to indicate the kind of bursting charge as follows:

Black powder	**Slate color.**
Explosive "D"	**Yellow.**
T. N. T	**Green.**
T. N. T.-BP	**One half width green, other half slate color.**
Blind loaded	**Red.**

Fixed case ammunition boxes.

40. Boxes containing fixed ammunition (Plates 31 to 36) shall be plainly marked with black letters three-fourths of an inch high (except black-painted boxes containing armor-piercing projectiles which are marked with white letters), as follows:

On one side adjacent to removable cover or hinged top—

Caliber of gun; number of rounds.
Character of projectile and weight.
Type of fuse.
Kind of bursting charge.
Index number of powder.
Weight of charge.
Initial velocity.
Mark, manufacturer, and date of primer.
Name of depot at which ammunition was put up.
Date.
Initials of gunner in charge.
Initials of inspector in charge.

On each end—

Caliber of gun; number of rounds.
Index of powder.

41. Boxes containing ammunition fitted with night tracers or tracer fuses shall have a white band 2 inches wide encircling the middle of the box parallel to the ends. In the case of white boxes containing shrapnel the band shall be black.

42. Each ammunition box shall have wired to it a cloth tag giving the full information which is required to be stenciled on the side adjacent to the cover.

Cartridge tanks fixed case.

43. Cartridge tanks (Plate 37) have bodies of galvanized steel, and these shall not be painted. The *bottom* of these tanks shall be painted a color to indicate the character of the projectile as prescribed in paragraph 38 (*a*), while the *cover* shall be painted a color to indicate the kind of bursting charge as prescribed in paragraph 38 (*b*).

(*a*) Cartridge tanks shall be marked on the body (or bottom) with the full data prescribed for the sides of ammunition boxes in paragraph 40. The cover shall be marked with the following:

Caliber of gun; number of rounds.
Index of powder.

(*b*) The tracer band, if required, shall be painted on both cover and bottom, but should not be painted on the body of the tank.

(*c*) Cartridge tanks should be tagged like ammunition boxes, the tags to give full information regarding the ammunition as specified in paragraph 42.

(*d*) Tanks made of sheet steel painted will conform to the same requirements.

Saluting - ammunition box.

44. Ammunition boxes containing saluting or signal-gun charges (Plate 38) shall be painted lead color, except the top, which shall be painted half white and half red, and shall be marked with black letters, three-fourths inch high, as follows:

Top of box—

Caliber and "saluting" (or "signal gun").
Character and weight of charge.
Name of depot where prepared.
Date.
Initials of gunner in charge.
Initials of inspector in charge.

Front of box—

Caliber and "saluting" (or "signal gun").

45. As the previous distinction between blank charges for "saluting" and for "signal-gun" purposes has largely been lost and as special 3-pounder and 6-pounder "signal-gun" charges are no longer prepared except by special direction of the Bureau of Ordnance, the previous requirement of a box painted light blue for signal-gun charges is canceled and all boxes containing blank charges will hereafter be marked and painted in the standard manner prescribed for saluting charges. The characteristics of any special ammunition should be noted in the markings on top of the box.

46. Each saluting ammunition box should have wired to it a cloth tag giving the information shown on the top of the box. When saluting ammunition is prepared on board ship, new tags will be placed on the ammunition boxes giving the initials of the gunner or other officer who supervised the work. (Ordnance Pamphlet No. 20, App. K.)

Replacement sample tanks.

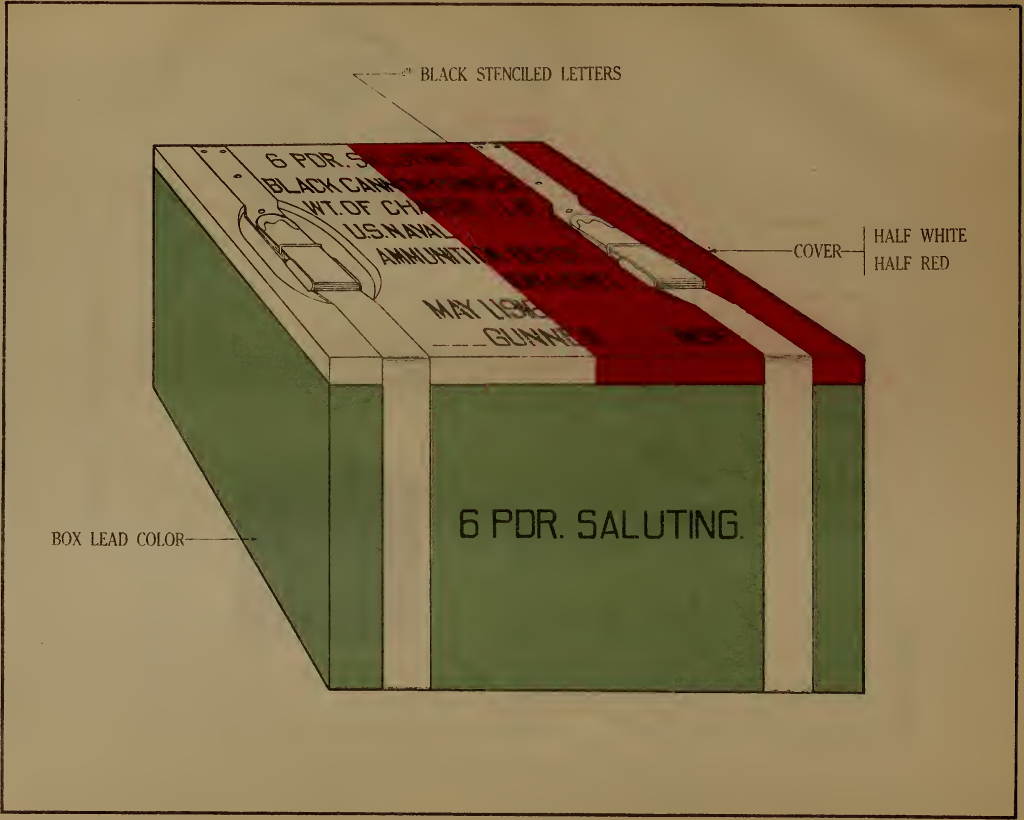
47. Four-inch and 5-inch tanks, full size or cut down, for replacement sample tanks (Plate 39), when issued for this purpose, shall be painted as follows:

(*a*) A red band shall be painted around the body of the tank, 6 inches wide, and shall have stenciled on it in white—

Replacement sample.
Index: SPD______.
Caliber.
Weight of charge.
Weight of sample.

(*b*) The top and bottom of these tanks will not be painted, but the top will be stenciled—

"Replacement Sample: SPD______."



Saluting Ammunition Box.

WILLIAMS WEBB CO INC WASH D C

PLATE XXXIX.

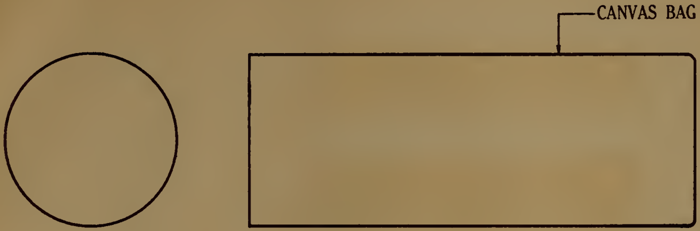


FIG. 1. REPLACEMENT SAMPLE BAG.

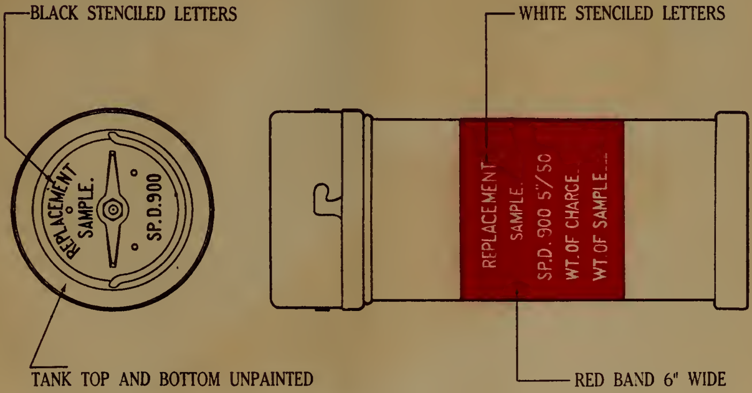
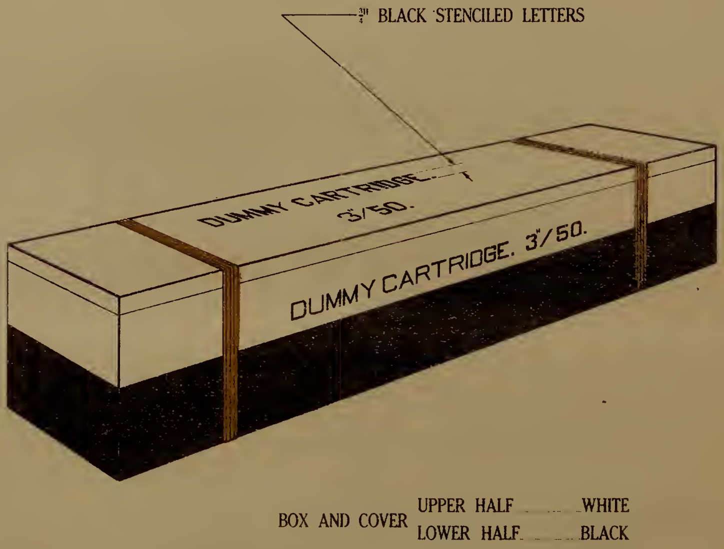


FIG. 2. REPLACEMENT SAMPLE TANK.

Replacement Sample Containers.

PLATE XL.


¾" BLACK STENCILED LETTERS
DUMMY CARTRIDGE.
3"/50.
DUMMY CARTRIDGE. 3"/50.
BOX AND COVER UPPER HALF .... WHITE
LOWER HALF .... BLACK

Drill Case Ammunition Box.

Drill ammunition.

48. Ammunition boxes containing dummy cartridges (Plate 40) shall be painted half black and half white with the dividing line parallel to the top of the box, upper half white. The box shall be plainly marked on top and front with black letters three-fourths inch high, as follows:

Dummy cartridge.
Caliber of gun.

49. Dummy bag charges (Plate 41) issued for drill purposes shall be plainly stenciled "Dummy" and powder tanks containing such charges shall be plainly marked "Dummy charge." (See United States Naval Ordnance Manual, Pt. V, art. 243.)

Aircraft bombs.

50. Aircraft bombs (Plate 42) will follow the same general scheme of marking as laid down for projectiles.

(*a*) The head will be painted to show the type of filler as follows:

T. N. T.	**Green.**	
Amatol	**Green.** **Yellow.**	**Line of demarcation to show percentage.**
Gas	**Red.**	

(A geometrical figure denoting the type and kind of gas-producing material will be painted on the head, in a manner similar to that used in painting projectiles.)

Incendiary	**White.**
Dummy	**Slate.**

(*b*) The type of bomb will be shown by the painting of the remainder of the body as follows:

Demolition **Antisubmarine** **Incendiary**	**Large capacity thin walls**	**Green.**
Fragmentation		**Slate.**
A. P.		**Black.**

(*c*) A white band 4 inches wide will be painted around the body at the center of gravity. The type mark and modification of the fuse will be stenciled on this band in letters 2 inches high.

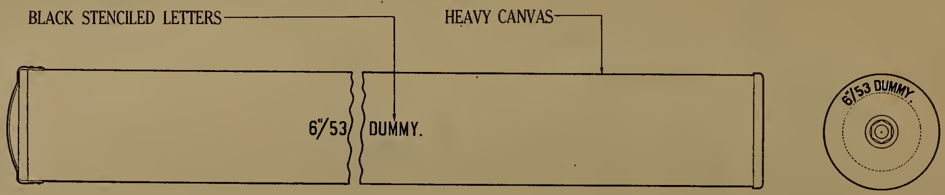


FIG. 1. DUMMY BAG CHARGE

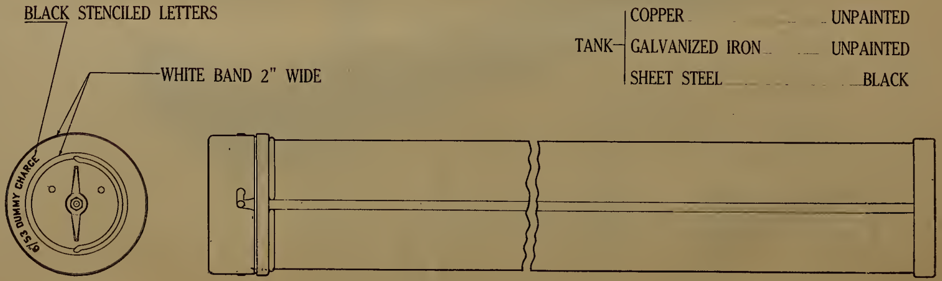
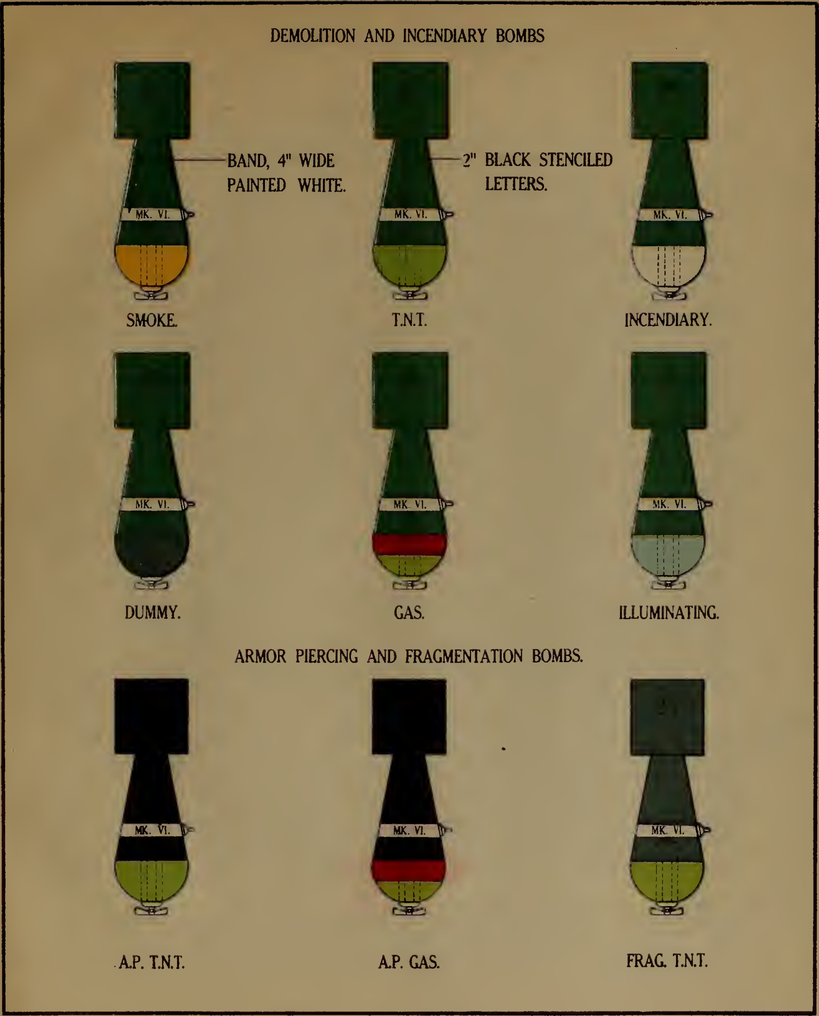


FIG. 2. DUMMY CHARGE POWDER TANK

Drill charge Ammunition Containers.

PLATE XLII.



Aircraft Bombs.

Chapter XIX.

PYROTECHNIC MATERIALS.

Pyrotechny.

1. Present-day pyrotechnic materials have resulted from a gradual development from fire. Pyrotechny, or the art of fire, is usually considered as the art of producing pleasing scenic effects by means of fire. The effects formerly utilized for display purposes lend themselves readily to many uses in the art of war, and consequently recent developments in this direction have been very rapid. Fire was originally used considerably in various forms of worship. Priests used many secrets concerning the nature and operations of the element for the mystification of the people. The knowledge they gained was later passed on to magicians and then to the alchemists. The change from alchemy to chemistry followed, and eventually the art of fire has been taken up by the scientist to produce modern pyrotechnics. In the use of the materials as required for military purposes, the art of pyrotechny is now restricted more particularly to the production of aerial fire.

Material used.

2. The effects desired in scenic displays tended toward a variety of colors, as well as the display of fire in various forms and patterns. The materials used were saltpeter, sulphur, charcoal, iron, and salamoniac. With this small variety beautiful effects were obtained, but modern chemistry has added many other materials to the list of available substances, such as phosphorus, arsenic, mercury, barium nitrate, magnesium salts, lime salts, potassium nitrate, potassium chlorate, aluminum, resin, strontium, carbonate and oxalate, potassium permanganate, sodium oxalate, and other metals, so that a great variety of lighting, smoke, and other effects may be obtained. The rocket has been known and used for many decades and has been made in various sizes. The modern improvements consist in the star arrangement and the substitution of various colored smokes for the fire. At one period rockets were used for projectiles in offensive and defensive operations.

Kinds of pyrotechnics.

3. Pyrotechnic materials are provided by the Bureau of Ordnance, either manufactured at a Government plant or obtained from private manufacturers. They consist of star rockets, smoke rockets, Very's stars, rifle lights, blue lights, red lights, wing or landing flares. Certain other pyrotechnic signal material is provided by the Ordnance Department of the Army, and sometimes used by the Navy. Description of such materials is obtained from Army publications. The development is still continuing in this branch and changes and additions may be expected.

Rocket.

4. The most commonly used form of pyrotechnics for signaling and sometimes for illuminating purposes is the rocket. It is in effect a projectile, containing a composition which, as it burns, generates sufficient gas which, as it escapes at the base, drives the rocket forward by reaction against the air. The same principle is involved as in gun recoil or water-jet propulsion of a vessel. The rocket case is always cylindrical, generally formed of pasteboard covered with tin, partly filled with the propelling composition, and, for military uses, has, in addition, a burster charge to be set off at the end of the flight for expelling the signaling contents, either stars, serpents, smoke, or illuminating material. The case is given a certain fixed amount of choke in order to get the proper gas discharge. A stick or staff is always attached to a rocket to give it stability in flight. It acts as a counterbalance against the weight of the rocket, so that the action of the gases, from combustion within the air chamber of the rocket, is downward, thus making the course of the rocket upward. Light wood is used, generally pine. The end attached to the rocket should be square in section and of a thickness equal to one-half of the diameter of the rocket, then tapering toward the tail to one-fourth of this size. The length and balance of the stick has an important effect on the flight, as the longer it is made the more nearly vertical the flight. The rocket with stick attached should balance about two case diameters from the lower end of the rocket body. Care should be taken to see that the stick is securely fastened to the rocket to insure a good flight. A rocket should be placed at an angle of 70° to the horizonal for firing.

Navy rocket.

5. There are a number of old type Navy rockets still in service, but no more will be manufactured, as this type will eventually be replaced by the shower type. The Navy old type consists of a thin tin cylinder lined with several ply of heavy paper. The rocket composition or propelling charge consist of refined niter, willow charcoal, meal sulphur, and meal powder in definite proportions by weight. In assembling a rocket the paper is rolled on a former and pasted together with flour paste and the choke is formed by wrapping with twine while still wet. The paper is then inserted in the tin case and allowed to dry. The tin case is placed in a steel mold, so fitted to support the choked end and to cause a spindle to project up through the choke. A clay plug is first pressed into place $\frac{1}{4}$ inch thick after pressing. The rocket composition is then added, a small amount at a time, and compressed under a pressure of $2\frac{1}{2}$ tons. When the case is filled to $\frac{1}{2}$ inch from the top another clay plug is made and compressed in place, and through this a piece of quick match is inserted. The conical top is then put on containing the stars and a small quantity of rocket composition, which is fired with the quick match when the rocket composition ignites the latter. When thus made the case is withdrawn from the mold and a piece of quick match is placed in the aperture made by the spindle of the mold, the excess coiled up and the lower end covered with a paper seal to keep out moisture. The quick match is made by soaking cotton wicking in paste made of meal powder, vinegar, gum arabic, and alcohol. To get the rocket ready for firing, break the seal and let the quick match drop out so that it may be ignited. The rocket will attain a height of approximately 800 feet, the stars giving a white light.

PLATE XLIII.

NIGHT DISTINCTION TAGS, WITH DIFFERENT SHAPES, AS SHOWN.

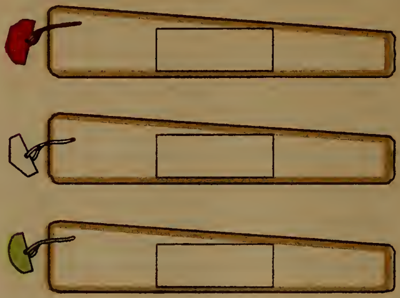


FIG. 1.

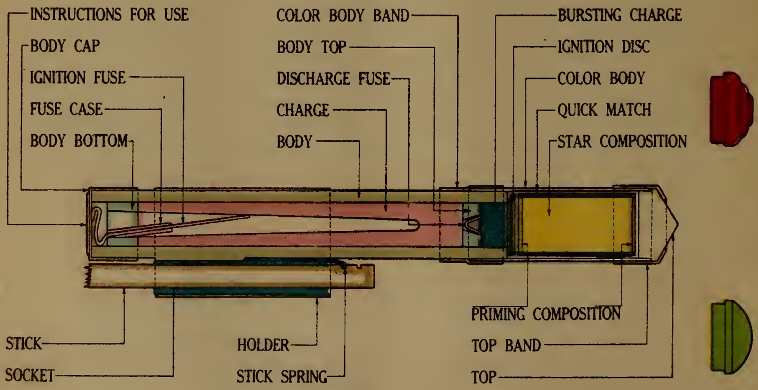


FIG. 2.

Star Rockets.

NIGHT DISTINCTION TAGS, WITH DIFFERENT SHAPES, AS SHOWN.

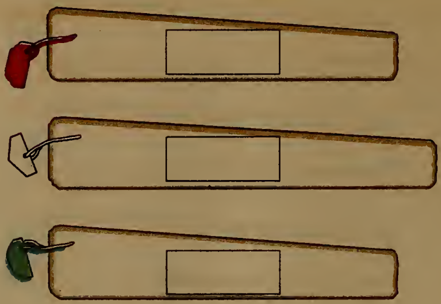


FIG. 1.

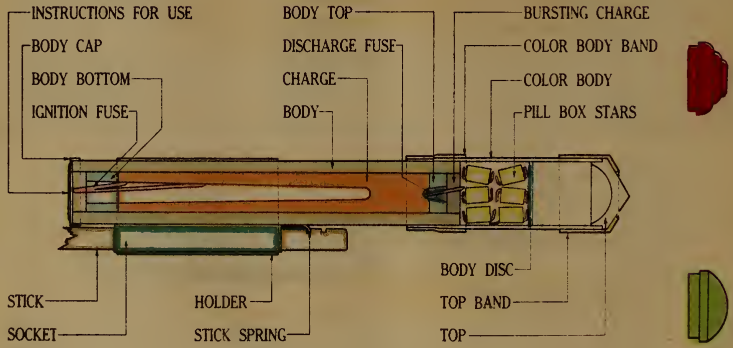


FIG. 2.

Shower Rockets.

PLATE XLV.

NIGHT DISTINCTION TAGS, WITH DIFFERENT SHAPES, AS SHOWN.

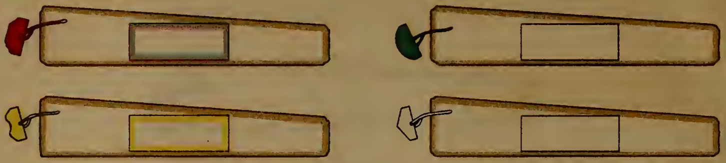


FIG. 1.

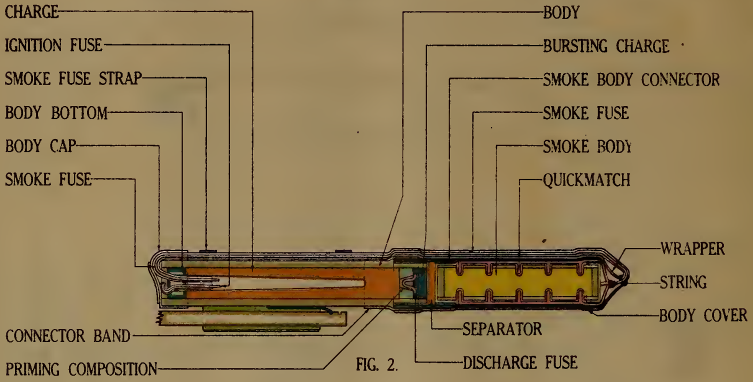


FIG. 2.

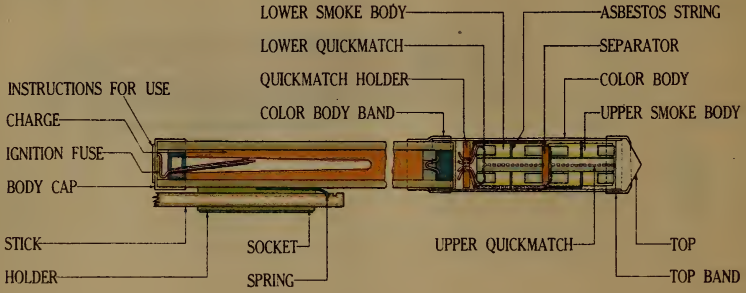


FIG. 3.

Smoke Rockets.

PLATE XLVI.

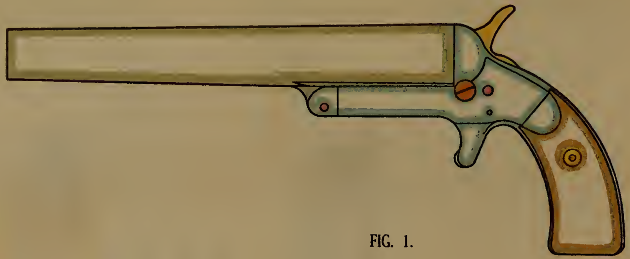


FIG. 1.

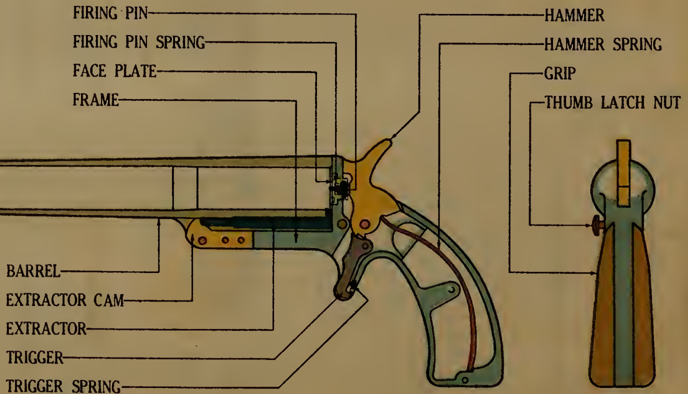


FIG. 2.

Very Signal Pistol.

PLATE XLVII.

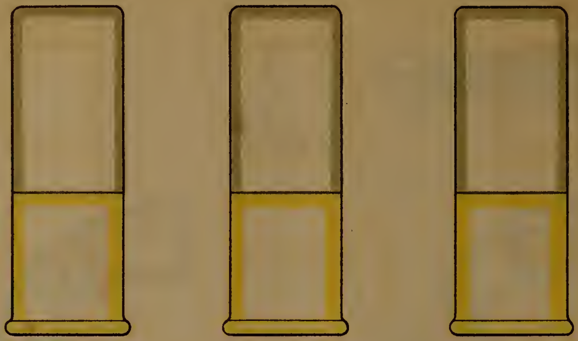
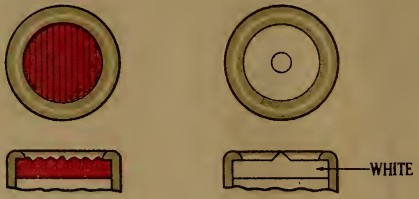


FIG. 1.



NIGHT DISTINCTION TOPS, WITH DIFFERENT SHAPES, AS SHOWN.

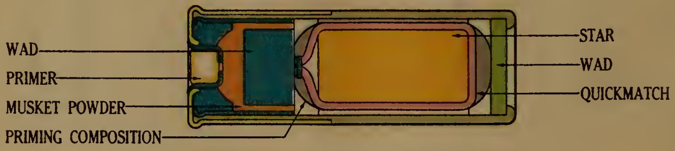


FIG. 2.

Very Signal Cartridges.

PLATE XLVIII.

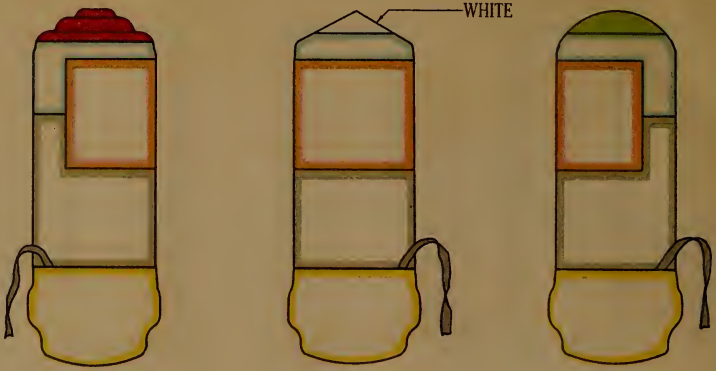


FIG. 1.

NIGHT DISTINCTION CAPS, WITH DIFFERENT SHAPES, AS SHOWN.

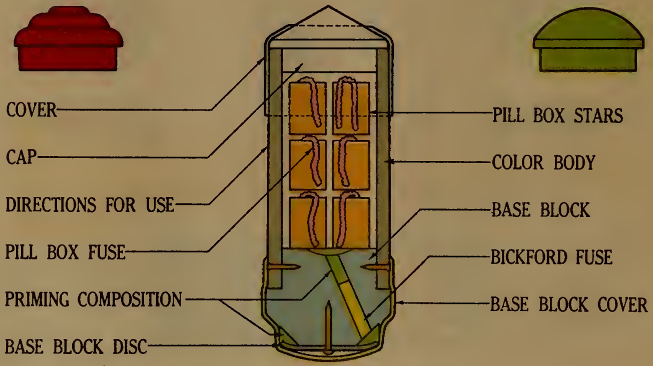


FIG. 2.

WILLIAMS WEBB CO.-INC WASH. D. C.

Rifle Signal Lights.

PLATE XLIX.

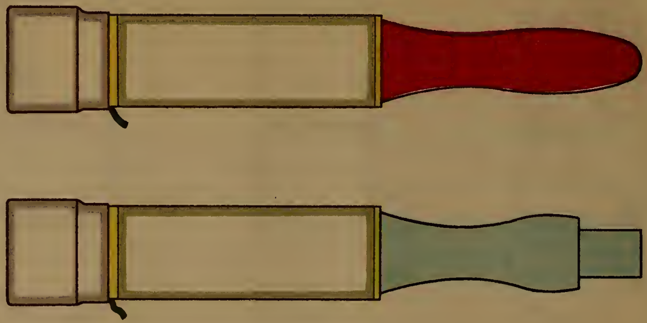


FIG. 1.

NIGHT DISTINCTION HANDLES,
WITH DIFFERENT SHAPES AS SHOWN.

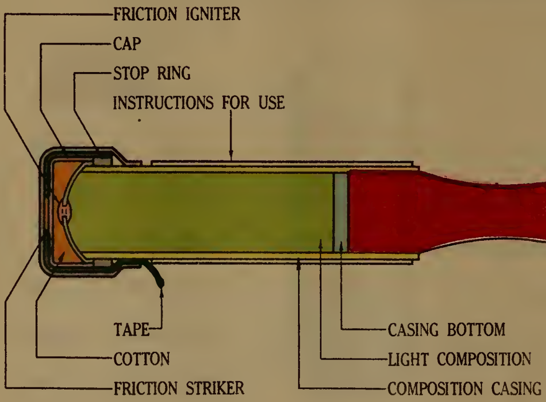


FIG. 2.

WILLIAMS WEBB CO INC WASH D C

Hand Signal Lights.

Star rocket.

6. The single-star meteor rocket (Plate 43), red, green, or white, is made in a manner similar to the old type Navy rocket. It has a case 1¼-inch bore and 12 inches long, with a head 1 5/16-inch bore and 4 inches long. The rocket composition consists of 8½ ounces of a composition suitable to give a rise of 800 feet, similar to the composition used in the old type. The stick is about 6 feet long, arranged to fit the socket on the case with a notch cut in the upper end to engage a spring in the socket to prevent its slipping out. The cap is made of wood of different shapes to permit distinguishing the different colors at night. The meteor star consists of a cardboard tube filled with the star composition, primed at both ends, and wound with quick match, the whole wrapped with a piece of paper of a color the same as the color of the star. In addition an ignition disk is placed in the star-chamber wound with quick match which is in contact through the clay plug with the rocket composition. The stars burn brightly as they fall through the air, and leave a brightly burning trail of good duration similar to a meteor. The bodies are painted drab color and the head the color to denote the color of the star. Each rocket is then wrapped in soft paper with some fused matches attached and sealed. A piece of twine is placed under the paper with a tag at the end, and is so fitted that by pulling the twine the covering is torn off. By dipping in melted paraffine the whole assembly is made waterproof. A label giving directions for use with other data regarding manufacture, etc., is then pasted on the exterior. The rockets are packed in sawdust, 12 to a wooden box, the sticks being packed separately, 6 in a bundle, and 18 bundles in a wooden box.

Signal rocket.

7. The signal-rocket parachute star is made in a manner similar to a meteor star rocket, except that the star is 1¼ to 1½ inches in diameter, and of sufficient length to burn from 45 to 60 seconds. They are made in three colors—red, green, and white—and there is attached to the star a parachute made of Japanese paper.

Shower rocket.

8. A shower rocket (Plate 44) is similarly constructed, except the garniture consists of 12 pill-box stars ½ inch in diameter and of sufficient length to burn from 8 to 10 seconds.

Identification marks.

9. The tops of all rockets and the shapes of the tags attached to the tear-off twine show the color of the stars.

Smoke rockets.

10. Smoke rockets (Plate 45) are similarly made except as to contents of upper chamber. There are two tubes for black smoke 1⅝-inch bore by 2¾ inches long, with both ends of each fitted to ignite simultaneously. A celluloid partition is fitted at each end of the smoke cylinders in which are placed the following chemicals: Hexachlorethane, magnesium powder, and anthracene, with an ignition powder composed of reduced iron and potassium nitrate. For the red, yellow, green, and blue smoke rockets, the smoke mixture is contained in a single-rolled paper tube, the following chemicals being used:

Red:

Potassium chlorate.
Lactose.
Paranitraniline red.

Yellow:
  Potassium chlorate.
  Lactose.
  Auramine.
  Chrysoidine.
Green:
  Potassium chlorate.
  Lactose.
  Auramine.
  Indigo.
Blue:
  Potassium chlorate.
  Lactose.
  Indigo.

The ignition powder is charcoal and potassium chlorate. The rockets are packed similarly to the meteor star rockets.

Very signals.

11. In addition to the rockets, signal cartridges are issued for use in the Very pistol. This pistol (Plate 46) is designed to take a 10-gauge shotgun, center-fire, brass-headed, paper shell. The pistol is a simple single-loading one, with a steel barrel about 9 inches long tapered at the muzzle. A lug on the underside is recessed for the extractor and arranged to fit in the hinge plate of the frame. The handle is bronze with two walnut sides. The frame is an irregular shaped piece of bronze to which the other parts are attached. The firing mechanism consists of trigger, trigger spring, hammer, main spring, faceplate, firing pin, and firing-pin spring. The extractor, a steel cylinder, fits into a recess in the lug of the barrel, and has a lug on its rear face which catches the rim of the cartridge as the barrel moves around the hinge pin. To operate, press in the barrel catch and break open the barrel by pressing it down. Insert the cartridge and return the barrel to its original position. Be sure the barrel is locked closed. (CAUTION.—Never fire a Very star in a shotgun or a shotgun cartridge in a Very pistol. The pistol may be single, double, or triple barreled.)

Very stars.

12. Very cartridges (Plate 47) are red, green, and white. Standard shotgun shells and primers are used. Each cartridge has the firing charge of about 25 grains musket powder and a star made of the following composition:

Red:
  Chlorate of potash.
  Strontium carbonate.
  Orange shellac powdered.
Green:
  Barium chlorate.
  Powdered orange shellac.

White:

Saltpeter.
Sulphide of antimony.
Sulphur.
Mealed powder.

The star is separated from the propelling charge by a felt wad to protect it from the violence of the explosion. The star consists of a tightly packed cylinder of the pyrotechnic material, reinforced with wire and wrapped with quick match. One end is primed with a small amount of black powder to insure ignition, which is so designed that the star comes to full brilliancy just prior to reaching the crest. The cartridges containing the different colored stars may be distinguished by the color and surface of the wad crimped in the end.

Packing of stars.

13. The stars are packed 12 to a cardboard box, each star in a separate compartment. The boxes are wrapped with paper and shellacked to keep out moisture.

Rifle light discharger.

14. Another method of signaling is offered by use or rifle lights. A special discharger is required, designed to fit over the muzzle of the rifle and lock in place with a bayonet joint over the front tight. The firing charge is contained in a special blank cartridge which is fired in the lock in the usual way. The gas from the blank cartridge ejects the rifle light from the discharger. As the recoil is excessive, the rifle should be rested on the deck or ground and held at the desired angle of elevation, usually about 70°. The discharger will fit any service rifle, and should the special blanks not be available, a service blank may be used, but will give less range than the special cartridge provided. Never use a service cartridge with a bullet for discharging a rifle light.

Rifle light.

15. The rifle light (Plate 48) consists of a cardboard tube with wooden base and head plug, and containing 12 stars of either red, white, or green color. On discharge, the priming composition in the base plug ignites a fuse which is so timed that it will light off an additional amount of priming composition and eject the stars from the tube as it reaches the top of the trajectory. As with rockets, the color of the paper and the shape of the head plug denote the color of the stars. Special types of these lights have been tried with 1, 3, and 6 star combinations, and also with parachutes attached.

Blue light.

16. The blue signal light (Plate 49) consists of a tube fitted with a handle and containing a special composition. The upper end is closed by a cover with a small amount of cotton inside of it. The outside of this cover is coated with a substance similar to that found on safety-match boxes for igniting safety matches. The burning composition at the upper end of the tube is covered with a piece of cloth impregnated with an igniting compound similar to that found in safety-match heads. To operate, remove cap, invert same and scrape it across the upper end of the tube, thus causing ignition in a manner similar to striking a match on a box, but do not hold the light vertically as burning particles will drop from it. The burning composition may ignite the deck or other articles, so care should be exercised in selecting the proper place for burning the light. The end of the handle is cut down as a distinguishing mark for night work. The whole light is wrapped with paper and waterproofed, and fitted with a tear-off strip for removing the cover.

Distress signal. **17.** The red distress signal (Plate 49) is similar in construction to the blue signal light, but has different markings. It is designed to burn 2½ minutes.

Handling pyrotechnics. **18.** Pyrotechnic material is to be considered a fire risk and treated accordingly. Each vessel is assigned certain quantities of each type according to her allowance list. When the store is drawn on for use, care should be exercised to see that the material which has been on board the longest time is issued first. This type of material may deteriorate so in storage, as it gets old, that failures may be expected. Consequently, the latest manufactured should be retained for service use. The date of manufacture appears on each article and container. If pyrotechnic material becomes moist it will not function properly, hence the storage place must be kept dry. As this material is used up in exercises, replacements to complete allowances will be filled by the ammunition depots on request of a commanding officer.

Chapter XX.

INTERIOR BALLISTICS.

1. The study of ballistics includes the study of the general system by which a projectile is fired from a gun to hit a distant target. It is readily divided into two branches, i. e., exterior ballistics, dealing with the flight of the projectile after leaving the muzzle of the gun, and interior ballistics, dealing with the phenomena which take place within the gun. The artillerist is more interested in the subject of exterior ballistics, for within the realm of this subject are found the factors with which he must deal in order to obtain the maximum effect of the implements placed at his disposal. The subject of exterior ballistics is treated in the Naval Academy book "The Groundwork of Practical Naval Gunnery or Exterior Ballistics." The subject of interior ballistics is a matter of great concern and study for the designer, as the form of the gun, the rifling, the length of bore, and the powder must be such that the projectile is ejected with the greatest muzzle velocity obtainable. For naval practice, the demand is for the highest practicable velocity and flat trajectory. The designer, to produce the required results, must, from a study of interior ballistics, so design the gun and ammunition that undue strains may not be produced, and that the gun will be able to fire a great number of rounds without undue wear or erosion. As these different requirements do not go together, it is necessary to determine a velocity which must be of the nature of a compromise.

Use of interior ballistics.

2. In laying down a new gun it is not possible to fix any requirements alone for either the gun, the powder, or the projectile, as the effects of changes in any one reflect in general in the designs of the others. The final answer is obtained only after a consideration of all factors. The gun has fulfilled its requirements when without undue strain it has delivered the projectile at muzzle at the required velocity in true flight. Effects acting on the projectile thereafter are within the province of the artillerist in causing the projectile to arrive at a predetermined place. The connecting link then between the designer and the artillerist is the velocity of the projectile and its true flight.

Extent of interior ballistics.

3. The field of interior ballistics covers the determination of the velocity, the accompanying pressures and their action on the gun and projectile, the effect on the velocity and pressure of changes in powder, weight of charge, density of loading, volume and form of the powder chamber, weight of projectile, the ignition of the charge, the rifling and projectile band.

Gun Requirements.

4. A gun is a mechanical device, composed essentially of a tube, closed at one end at the moment of firing, capable of containing a projectile and a propelling charge and of so controlling the explosion of the charge as to discharge the projectile with a high velocity. It must fulfill the following conditions:

Mechanical. (*a*) Its construction must be such as to withstand the pressure and other actions of the rapidly burning propelling charge. After the powder pressure in the gun has been determined by interior ballistics the strength of the gun is governed by the study of the "elastic strength of guns." The construction of the gun must give the required strength and the arrangement of parts is decided upon by the designer in accordance with the special requirements for the gun under consideration.

Ballistic. (*b*) The gun must produce a given ballistic result, i. e., must deliver a certain weight of projectile at a given velocity with the minimum possible stresses on the gun. These conditions are the special field of the study of interior ballistics.

Service. (*c*) The gun must easily fulfill the necessities of the service relating to the working of the breech, the loading, training, and aiming of the gun. The last two, however, are more properly matters of the gun mount rather than the gun itself.

Powder. **5.** Present gun powder is a "smokeless powder" composed of a single chemical element—cellulose nitrates—colloided by the addition of a small amount of solvent. Some foreign countries use a so-called double base smokeless powder made from cellulose nitrates, and nitroglycerin, such as the cordite used by England. The manufacture of smokeless powder is described in chapter 8. To function satisfactorily as a propellant, powder must burn relatively slowly and not detonate. When a substance detonates, it turns almost instantly into a gaseous state, subjecting its container to a great shock and large stresses. Should such a substance be used in a gun it would be most inefficient as will be seen later from a consideration of the pressure curve in the bore. A substance which burns slowly enough so that the volume of gases is added to as the projectile moves down the bore results in more efficient application of the energy and permits of lower maximum pressures. The attempt to adapt high explosives in the form of guncotton led to the development of the present type of propellants.

Powder chamber. **6.** That portion of the gun which contains the powder before firing is the powder chamber. The projectile is seated in the bore and with its base closes the front end of the chamber while the breech block closes the rear end, thereby forming the chamber in which the gases are burned. The chamber volume is an important consideration in the study of interior ballistics.

Density of loading. **7.** The density of loading is the ratio of the weight of the charge to that of a volume of water sufficient to fill the powder chamber. The volume of the powder chamber is usually denoted by the letter "S," the weight of charge by "W," and the density of loading by $\triangle$. One pound of water occupies 27.68 cubic inches, then

$$\frac{W}{\frac{S}{27.68}} = \text{density of loading of } \triangle = \frac{27.68\,W}{S}$$

8. The bore of the gun is the part of uniform diameter traversed by the projectile, usually called the "travel of the projectile," and is denoted by the letter "u." **Travel of projectile.**

9. Mathematical analysis, based upon certain fundamental assumptions, allows the deduction of various formulas concerning the elements of a gun and ammunition, from which the action of the gun may be predicted. Formulas giving the interrelation of these elements permit the determination of any unknown when the others have been determined. The use of such formulas may be appreciated in designing a gun or powder. For instance, for a given muzzle velocity and limiting maximum pressure, it is possible with present-day formulas to determine the volume of the powder chamber and weight of charge. From these the pressures existing successively in the bore as the projectile travels down the gun may be found and the gun may then be designed to afford sufficient strength throughout its length. From a consideration of the velocity and pressure the most suitable powder may be designed for a gun of similar proportions but of different caliber, or the adaptability of a powder for another gun or the variations to be expected by varying the weight of charge, weight of projectile, etc., may be found. **Use of formulas.**

10. From a rough estimate of the phenomena taking place in a gun, the number of variables concerned, the fact that the volume of gases is constantly changing due to the motion of the projectile, the difficulties in measuring certain effects, such as the loss of heat in the metal, leakage around the band, expansion of chamber and bore, recoil energy, air pressure in front of projectile, friction of gases, the resistance of the projectile, and many other considerations, it may readily be seen that the problem of expressing the laws governing interior ballistics is by no means a simple one. The first deep study of interior ballistics was taken up by General Rodman, of the United States Army. The French followed with exhaustive research, which resulted in formulas for the action of geometrically grained black powders in a gun, as worked out by Emile Sarvau, engineer in chief of the French powder factories. He considered the elements of granulation, density, and velocity of combustion of the grain, both in air and in the gun, and obtained working formulas which gave results confirmed by experimental firings. Certain assumptions, necessarily not absolutely exact, were made to provide an initial point for mathematical analysis, and the constants employed in his formulas were so modified, after experimental firing, as to obviate the effect of these inexact assumptions. These assumptions were: (1) The gases expand adiabatically; this, of course, neglects the heat expended in heating the walls of the gun and the bore of the gun; (2) the time required for the complete inflammation of the charge is negligible as compared with the time of combustion. The Sarvau formulas giving expressions for the velocity and the pressure at any point of the travel of the projectile have been adopted with but slight modifications as standard for black powder. Black powders burn more rapidly than equal thicknesses of smokeless powders, so when the change to the latter occurred, the Sarvau formulas were found not sufficiently **Development of interior ballistics.**

accurate. Larger powder charges, burning more slowly, without undue pressures, produced greater density of loading, more volume of gas, greater energy, and higher muzzle velocity. Recent investigators have modified the Sarvau formulas and adapted them to the use of smokeless powder. LeDuc has deduced some semiempirical formulas from the results of experiments for calculation of interior ballistics and which have given very satisfactory results at the naval proving ground in computing the powder pressure in bore and the velocity of the projectile in bore when the maximum powder pressure is known. These latter formulas were derived partly from theory and partly from the results of firing experiments.

Application of formulas.

11. The results obtained by the use of formulas are not infallible, but in general are close approximations to actual results obtained on firing with elements calculated from the formulas. Calculated results are always checked by actual firings at the proving ground to insure against inaccuracies. The calculations, however, provide a starting point for such tests. When information is desired, in advance of any possible proof work, as in planning ammunition stowage and loading arrangements aboard new vessels, necessitating knowledge of weight and volume of charges and, in designing guns and powders, invaluable data are afforded by the application of interior ballistic formulas. In other words, while the results obtained from theory are not to be regarded as final without proof, yet the knowledge of the principles of interior ballistics is and has been vitally necessary to the development of naval ordnance.

Formulas used.

12. The subject of smokeless powder, ignition, combustion, granulation, and density is discussed in chapter 8. As may be seen therein, smokeless powder, even though made of a standard nitration and uniform shape of grain, may be so manufactured, by altering the web thickness, that different speeds of burning may be obtained, and that in fitting a powder to a gun one somewhat slower than the maximum powder is most efficient. In order to compute easily and quickly the curve of pressures in the bore, recourse is had to the LeDuc formulas. The following symbols are used:

w=weight of charges of smokeless powder in pounds.
p=weight of projectile in pounds.
Δ=density of loading, which varies from 0.4 to 0.7.
S=volume of powder chamber in cubic inches.
V=muzzle velocity in foot-seconds.
u=travel of the projectile in the bore in feet.
A=cross-section of bore in square inches.
g=acceleration of gravity in foot-seconds.
δ=specific gravity of powder varying from 1.54 to 1.62.
P=pressure on base of projectile in foot-tons.
B=powder constant, depending on form and dimension of grain, amount of volatiles, and temperature of powder, largest for slow powders.
"a" and "b" gun and powder constants.

A more complete discussion of interior ballistics may be found in Ordnance Pamphlet No. 411, and as the derivation of the forumlas used is outside the scope

Powder Test No. 2997.

From: Inspector of Ordnance in Charge.

To: Bureau of Ordnance.

der: {*Designation I. H. F. D. 9.*
Index No. S. P. D. 1365.}

Date.	Time.	Projectile.					
		Make.	Year.	Lot.	Ba		
					To base.	Width	Diam.
Oct. 19	8.44	N. G. F.	......	......	1½	4	12.174
Do.....	8.54	...do....	......	......	1½	4	12.173
Do.....	9.05	...do....	......	......	1½	4	12.173
Do.....	9.16	...do....	......	......	1½	4	12.174

12 in 50 caliber.

Mod. 1 No. 180—L.

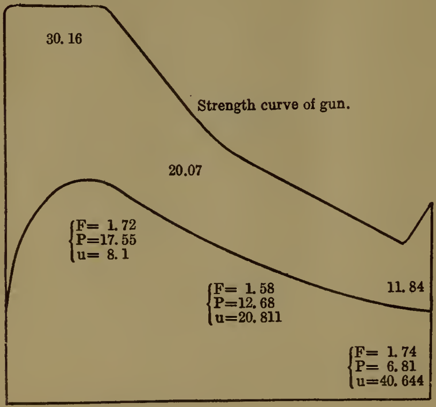
14611 cubic inches.

?.

3.2.

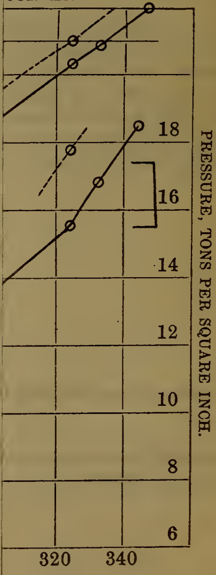
Weather: Fair. Temperature, F.: dry bulb 60.5; wet bulb 59.5.
Barometer 30.11 at 66° F. Wind 0 knots at o'clock.
(XII o'clock head wind.)

Cotton: Tennessee fiber.		Dry grain: length	1.61
Die: diameter	.985	diameter	.697
number of pins	7	Diam. perforation	.057
pin diameter	.072	Average web	.132
Length of cut	1.75	Outer web	.128
Nitration	12.64%	No. grains per lb.	30.6
Diphenylamine	.45%		



Curve of

CURVES.



of this manual, the basic formulas alone will be set forth and a discussion given on their use.

Problems.

Formulas.—For convenience the interior ballistic formulas most often used are grouped together.

$$\delta=1.672-(.0178\times \mathrm{T.V.}) \qquad \text{I.}$$

$$\Delta=\frac{\varpi\times 27.68}{S} \qquad \text{II.}$$

$$v=\frac{au}{b+u} \qquad \text{III.}$$

$$a=6823\Delta^{\frac{1}{12}}\left(\frac{\varpi}{p}\right)^{\frac{1}{2}} \qquad \text{IV.}$$

$$b=\beta\left(1-\frac{\Delta}{\delta}\right)\left(\frac{S}{p}\right)^{\frac{2}{3}} \qquad \text{V.}$$

$$b=\frac{Q\times\varpi^{\frac{7}{8}}}{P\ \mathrm{max\ (gauge)}} \qquad \text{VI.}$$

$$P=\frac{R\times u}{(b+u)^3} \qquad \text{VII.}$$

$$R=6.75\ b^2\ P\ \mathrm{max\ (gauge)} \qquad \text{VIII.}$$

$$Pm=\frac{4}{27}\times\frac{a^2\times p}{2240\times g\times A\times b} \qquad \text{IX.}$$

Is the powder suitable for the gun?

Interior ballistics finds its daily service use in answering this question, which, naturally, must be answered for each powder index manufactured. The firings at the proving ground give the data from which to calculate the powder pressure at every point along the bore. A curve of these bore pressures is drawn and superposed upon the strength curve of the gun. If the ratio *f*, factor of safety, everywhere along the bore exceeds 1.4, the powder is considered suitable for the gun. This work forms a large part of the daily routine at the Naval Proving Ground at Indianhead, Md.

To calculate a pressure curve.

A powder, I H F D, lot 9, has been fired in the 12-inch–50 gun. The powder test sheet herewith shows the results of the firing on October 19, 1915, and from its curve of velocities measured by the chronographs the charge of 322.5 pounds is picked off as giving the desired velocity.

In assigning the service charge for any gun the fact must be taken into consideration that the powder is generally of necessity proved in guns that have been fired before and usually many times, while the charge to be assigned is one that in a new gun will give the desired muzzle velocity. Therefore the wear of the gun must be allowed for. The exact loss due to this wear has been determined from many actual firings, and has been tabulated.

NAVAL PROVING GROUNDS.

INDIAN HEAD, MD.,

October 25, 1915.

POWDER TEST SHEET.

Powder Test No. 2997.

From: Inspector of Ordnance in Charge.

To: Bureau of Ordnance.

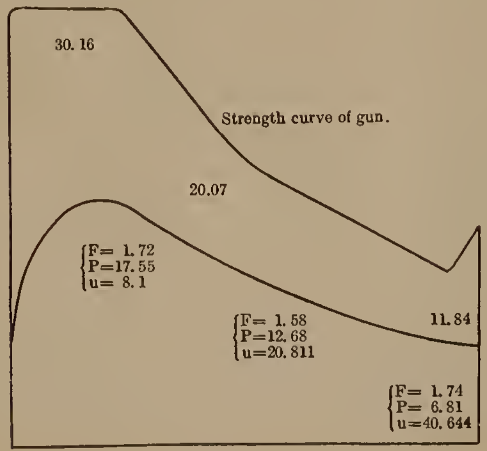
Powder: {*Designation I. H. F. D. 9.*
Index No. S. P. D. 1365.

Date.	Time.	Projectile.									Powder.			Chamber pressure.							Muzzle velocity.			
		Make.	Year.	Lot.	Band.				Weight.	Shape.	Heated.		Charge.	Gauges.						Mean.	Chronographs.			Mean.
					To base.	Width	Diam.	Lip.			From °F.	Hours.		1	2	3	4	5	6		A	B	C	
Oct. 19	8.44	N. G. F.	......	......	1½	4	12.174	12.470	868	Slug....	65	66	230	7.94	7.86	7.19	......	......	......	7.66	2130	2130	2130	2130
Do.....	8.54	...do....	......	......	1½	4	12.173	12.478	870	...do....	65	66	330	16.20	16.84	16.84	16.44	16.68	16.76	16.63	2872	2872	2872	2872
Do.....	9.05	...do....	......	......	1½	4	12.173	12.484	871.5	...do....	65	66	344	18.89	19.08	18.71	18.08	18.71	17.99	18.58	2967	2967	2967	2967
Do.....	9.16	...do....	......	......	1½	4	12.174	12.485	867.5	...do....	65	66	322	15.30	15.59	15.73	15.14	15.66	15.66	15.51	2824	2824	2824	2824

Gun 12 in 50 caliber.
Mark VII Mod. 1 No. 180—L.
Chamber. 14611 cubic inches.
Rifling: Depth of grooves .075.
number of grooves 72.
pitch 1/50 to 1/32.
Number of sections 4.
Ignition per section 300 grams C. P.
Previous rounds: {actual 52.
equivalent service 53.2.
Erosion loss: {83 f. s.
2.0 tons.

Weather: Fair. Temperature, F.: dry bulb 60.5; wet bulb 59.5.
Barometer 30.11 at 66° F. Wind 0 knots at o'clock.
(XII o'clock head wind.)

Cotton: Tennessee fiber.		Dry grain: length	1.61
Die: diameter	.985	diameter	.697
number of pins	7	Diam. perforation	.057
pin diameter	.072	Average web	.132
Length of cut	1.75	Outer web	.128
Nitration	12.64%	No. grains per lb.	30.6
Diphenylamine	.45%		

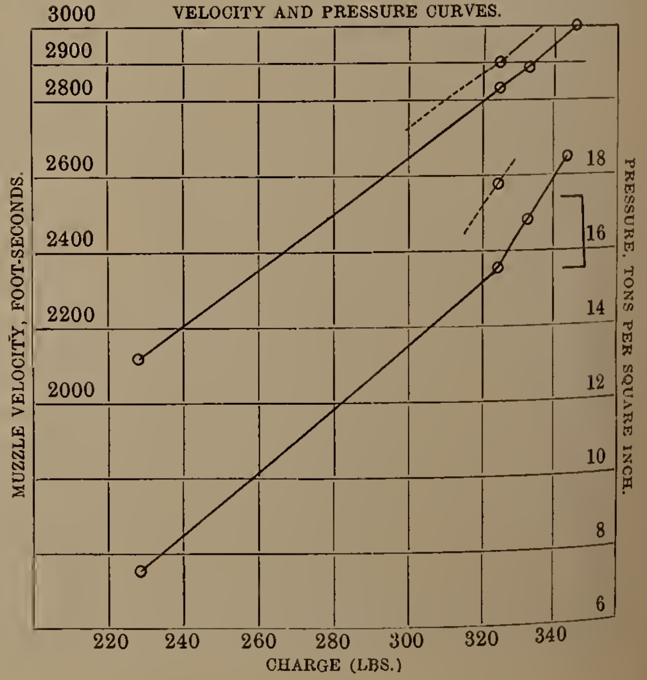


Curve of bore pressure.

Time in dry house: 116 days at 39.4° C.
66 days without heat.
German test, 135° C. {Violet 95′
Explosion 5 hrs. +
Surveillance test 65° .5 C. days.
Heat test of pyro. 65° .5 C. 35+minutes.
Total volatiles, W. P. method, {dry house condition 6.73%
as received 7.00%
Original firing test {Date This date.
Record No.
Lot contains 100,123 pounds.
Disposition: 100,123 pounds to Naval Mag., Lake Denmark, N. J.

	Bureau Assignment.	P. G. ASSIGNMENT.
	12″—50	Gun: 12″—50 cal.
	Mk. VII.	
	2,900 f. s.	Muzzle velocity: 2,900 f. s.
	1,200 grams.	Ignition: 1,200 grams C. P.
(even lbs.)	323 lbs.	Charge: 322.5 lbs.
	17.5 tons.	Pressure: 17.55 tons.

VELOCITY AND PRESSURE CURVES.



28015—21. (To face p. 255.)

In the case in question it is seen that the loss due to erosion consists of 83 foot-seconds in velocity and of 2 tons in pressure. Draw dotted lines parallel to the actual curves at the above distances and from these pick off the charge required to give a muzzle velocity of 2,900 foot-seconds, and the pressure that will be caused by this charge when used in a new gun. It is important to note that this decrease of pressure due to erosion is proportionally greater than the decrease of velocity; i. e., erosion decreases pressures more proportionately than it does velocity. The bearing of this fact upon all powder tests can readily be appreciated.

Solution

From equation VI obtain b, taking log Q from Table I.

$\omega=322.5$ ....log.. 2.50853
One-sixth..........log.. .41809
P max (gauge)=17.55..............colog.. 8.75572
Q.....................................log.. 9.52310

$b=16.049$............................log.. 1.20544 and $\frac{b}{2}=8.0245$; $\frac{3b}{2}=24.0735$.

TABLE I.

Gun.	Mark.	Log. Q.	U (total).
16-inch, 45....		9.24345	51.821
14-inch, 50....	IV	9.36818	50.250
14-inch, 45....	I	9.38686	45.204
13-inch, 35....		9.45155	31.211
13-inch, 35....	I and II	9.45226	31.193
12-inch, 50....		9.52310	42.165
12-inch, 45....	V–5 and VI–3	9.52330	37.743
12-inch, 40....	III–3	9.51251	32.751
12-inch, 35....	I	9.53776	28.907
12-inch, 35....	II	9.53776	28.851
10-inch, 30....	I	9.73723	20.954
10-inch, 40....		9.70761	27.302
8-inch, 35.....		9.98716	20.537
8-inch, 45.....		9.94946	24.971
7-inch, 45.....		0.09235	21.651
6-inch, 40.....	IV	0.30014	17.162
6-inch, 40.....	VII	0.30014	17.188
6-inch, 45.....	IX	0.30014	18.512
6-inch, 50.....	Arms. V	0.31411	22.312
6-inch, 50.....	VIII	0.26651	20.732
5-inch, 40.....	II and III	0.50802	13.982
5-inch, 50.....	V	0.46379	17.917
5-inch, 50.....	VI 3,000 f. s.	0.46488	17.917
5-inch, 51.....	VII and VIII	0.46530	17.929
4.7-inch........		0.58832	17.173
4-inch, 40.....		0.75121	11.198
4-inch, 50.....	VII	0.70364	14.018
4-inch, 50.....	VIII	0.70364	14.018
4-inch, 50.....	IX	0.70364	14.018
3-inch, F. G....		1.16810	4.947
3-inch, L. G....	IV	1.13463	5.233
3-inch, 50.....		1.03594	10.658
6-pounder.....		1.38967	8.452
3-pounder.....		1.56387	6.560
1-pounder.....		1.89975	4.406

In actual practice the omnimeter can be advantageously used in the solution of the remainder of the problem, and at the proving ground it is generally used. In order to explain the method more fully, the solution by logarithms here follows:

From VIII it follows that $R=\frac{17.55\times 24.0735^3}{8.0245}$

17.55..................log 1.24428
8.0245 log .90442 colog 9.09558
24.0735 log 1.38155 3 log 4.14465
R.............log 4.48451

Now take three points in the travel of the projectile and calculate the bore pressures at each of these points, computing also the factor of safety at each of these points as the work progresses. The strength of the gun at the points used is taken from the strength curve of the gun.

From VII it follows that $P=\frac{R\times u}{(b+u)^3}$

Three values of u are taken. The remainder of the work is as follows:

$u_1=8.14$ feet................log .91062
$b+u_1=24.189$ log 1.38362
3 log 4.15086 colog 5.84914
R..........................log 4.48451 $f_1=\frac{30.16}{17.55}=1.72$
$P_1=17.549$ tons........log 1.24427

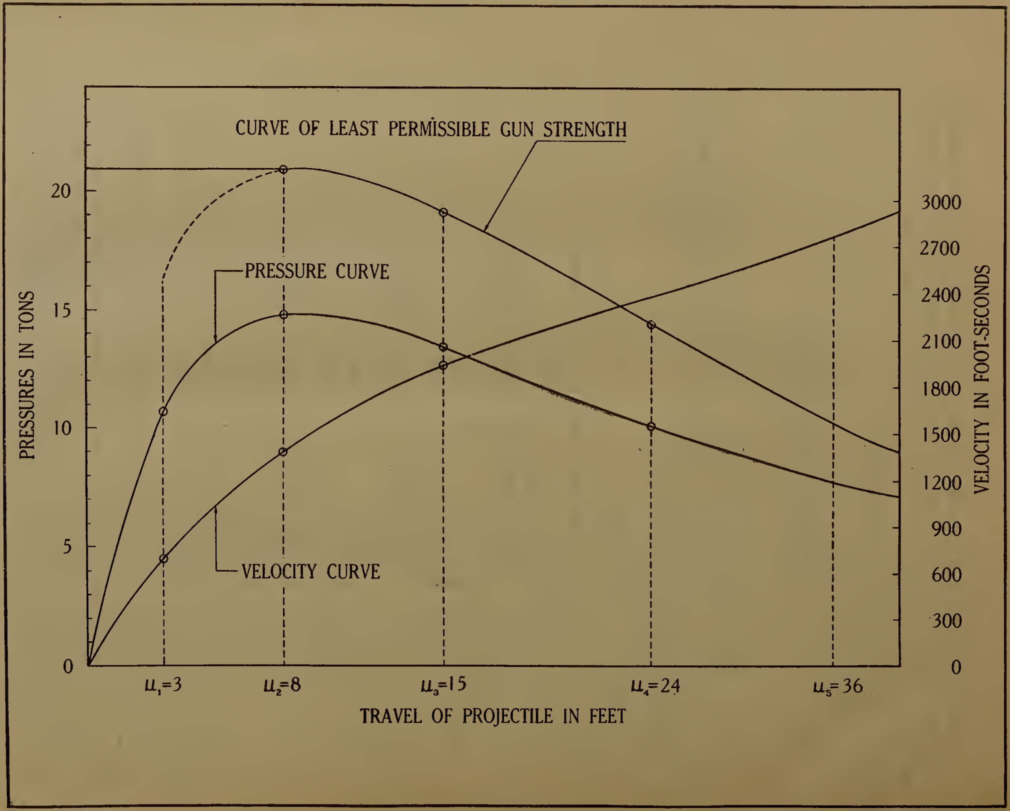
$u_2=20.81$ feet...............log 1.31827
$b+u_2=36.859$ log 1.56655
3 log 4.69965 colog 5.30035
R..........................log 4.48451 $f_2=\frac{20.07}{12.68}=1.58$
$P_2=12.68$ tons.........log 1.10313

$u_3=40.64$...................log 1.60895
$b+u_3=56.689$ log 1.75350
3 log 5.26050 colog 4.73950
R..........................log 4.48451 $f_3=\frac{11.84}{6.81}=1.74$
$P_3=6.807$ tons.........log .83296

Now draw the curve of pressures and superpose it upon the curve of gun strength. A graphic representation of the relations between gun strength and bore pressures is thus obtained.

This is seen to be a very strong gun, and as the strength curve is regular it is only necessary to work out a few points as above. The pressure curve is now one that agrees with the gauges. Plot it upon the powder-test sheet, and lay down the strength curve of the gun to the same scale. The factors of safety, f, are worked out at the various corners of the strength curve where the value changes. The test sheet therefore indicates at a glance the suitability of the powder. If the gun is unduly stressed at any point, the powder must be rejected for that gun.

PLATE L.



Gun Design Curves.

Maximum pressure is thus seen to be not the whole consideration. It is possible for powders in some guns to be so "slow" that, while only a low pressure is obtained at the breech, the muzzle pressure would be sufficient to burst that part of the gun. This is readily appreciated if pressure curves for powders of various "quicknesses" are plotted. The muzzle velocity being fixed the curve areas must all be the same, and decreasing the curve ordinate at one end of the gun can only result in raising the pressure at the other end.

Problem.—The proof of a 5-inch 50 Mark V gun at Indianhead gave as results: Velocity of 2,700 foot-seconds, gauge pressure of 15 tons, charge of 19.2 pounds of powder, shell weighing 50 pounds. Determine the bore pressures at travels of 8, 22, and 40 calibers.

Answer. 14.96 tons; 9.7 tons; and 5.3 tons.

The strength curve shows at these points strengths of 20.8, 14.6, and 6.5 tons. What is the factor of safety at these points and is the powder suitable for the gun?

Answer. 1.39; 1.5; 1.2. The gun is too weak for this powder.

To calculate reduced velocities.—Due to certain circumstances it is often necessary to use only a part of the service charge. Thus it was at the Dardanelles in 1915 necessary for the battleship *Queen Elizabeth* to use but three of the four sections of the charges for her 15-inch 45 guns in order to produce a good (large) angle of fall on shore, while at the same time reducing the wear on her guns. In order that she might fire accurately it became necessary for her officers to calculate the reduced velocity and then by exterior ballistics the proper sight bar settings were obtained.

From the service charge a value of a is obtained from IV. This a is used in III to give b. This b used in V gives β. It must be noted that Δ is different for the reduced charge. A new value of b for the reduced charge is then obtained from V. A reduced charge a is derived from IV. With these reduced charge values of a and b, the reduced value of the muzzle velocity is obtained from III.

Problem.—Given a 6-inch 50 gun, $v = 2{,}800$ foot-seconds; $\delta = 1.58$; $p = 105$; $\omega = 38$ pounds; $S = 2{,}101$ cubic inches. Calculate the velocity that will be obtained when a charge of but 30 pounds is used.

Answer. 2,375 foot-seconds.

Having thus determined the velocity that will be obtained, it becomes necessary for the gunnery officer to determine what sight-bar range to use for the actual range at which the firing with the low charge is to be done. This is a problem in exterior ballistics, the solution of which will be found in "The Groundwork of Practical Naval Gunnery or Exterior Ballistics, Alger, 1915," article 285, page 183, and Forms 1 or 2, pages 263 and 268, first noting the footnote, page 268.

Velocity given by same powder in guns of different caliber.—Solve for a in IV; then put a in III, and obtain b; then use this b in V obtain β. With this β the process is reversed for the other gun, and the velocity that a charge of this powder will give in it is thus obtained.

Problem.—A certain powder is fired in a 10-inch 30 gun using 90 pounds, a velocity being obtained of 2,000 foot-seconds. If 160 pounds of this same powder be used in the 13-inch 35 gun, what will be the velocity obtained?

Answer, 1,888.2 foot-seconds.

Data.

10″30	13″35.
$p=510$ lbs.	$p=1130$ lbs.
$S=6779$ cu. in.	$S=15068$ cu. in.
$\delta=1.56$	

To determine the proper dimensions for a new powder.—Considerable time, some three months, is required after the manufacture of a powder is commenced before an index of it is completed and ready for firing tests and issuance to the service. The powder must, therefore, be made on fairly accurate assumptions in order that it may suit the new type or caliber of gun in which it is to be used.

For example, it was necessary to determine what web should be used for the 16-inch 45 and the 14-inch 45 and 14-inch 50 guns, guns larger than any previously manufactured. A suitable value of β was found by computation. β was computed for all sizes of powders, by the use of formulas III, IV, and V, as indicated previously, and large numbers of these β's plotted as a function of the web. The curve was then extended and the proper thickness of the web picked off. Therefore, long before the guns were completed a powder of suitable dimensions was ready.

Problem on gun design.—Certain requirements that a new gun must fulfill are laid down before any work on the design is commenced, these requirements being taken from a consideration of the dimensions of guns already built.

Suppose a new 12-inch 50 gun is to be designed. The following approximate requirements will be laid down:

Shell = 870 lbs. Max. working pressure = 17 tons.
I. V. = 2900 f. s. Δ to be not greater than .65. δ = about 1.55.
Chambrage = 1.25. Length of chamber to be from 6 to 7 times its diameter.

Then the problem that must be solved before the design can be even roughly sketched is to determine—

(*a*) The weight of charge, π.
(*b*) The capacity of the powder chamber, S.
(*c*) Approximate dimensions of the powder chamber.
(*d*) The characteristic of the powder, β.
(*e*) At least five points of pressure and velocity curve, and construct the approximate curves.

Solution.—The diameter of the powder chamber will be by the conditions = 1.25×12, or = 15 inches.

The length of the powder chamber will be between 15×6, or 90 inches, and 15×7, or 105 inches.

Take 93 inches as a trial length. The total length of the gun take as 610 inches and allow 10 inches for the breech plug. The total travel of the projectile, u, is then equal to 610 minus 93 minus 10, or 507 inches. u in feet then is 42.25 feet. P has been taken as 17 tons, and therefore P max. for calculations is equal to 17 divided by 1.12 or 15.18 tons.

Next step must be the determination of the constant a from equations III and IV. This work is given in detail.

Take $M=\frac{u}{b}$, and from III there results

$$v=\frac{aM}{1+M} \text{ or } a=\frac{v}{M}(1+\mathrm{M}). \quad \text{Put this in IX, since } b=\frac{u}{M}$$

$$Pm=\frac{4\times a^2\times p\times M}{27\times 2240\times g\times A\times u}, \text{ or } a=\sqrt{\frac{27\times 2240\times g\times A\times u\times P_m}{M\times 4\times p}}$$

Take K as equal to $\frac{27\times 2240\times g\times A\times u\times P_m}{4\times p}$, $a=\sqrt{\frac{K}{M}}$

Eliminate a $\cdot \sqrt{\frac{K}{M}}=\frac{v}{M}(1+M)$ or $KM=v^2(1+2M+M^2)$,

which quadratic being solved

$$M^2+\left(2-\frac{K}{v^2}\right)M+1=O, \text{ and } M=\frac{-\left(2-\frac{K}{v^2}\right)\pm\sqrt{\left(2-\frac{K}{v^2}\right)^2-4}}{2}$$

With this value of M, using the data assumed, now find from IV the value of π

$$a=6823\ \Delta^{\frac{1}{12}}\left(\frac{\pi}{p}\right)^{\frac{1}{2}}$$

which becomes

$$v=6823\left(\frac{\pi}{p}\right)^{\frac{1}{2}}\Delta^{\frac{1}{12}}\frac{M}{M+1} \text{ and } \left(\frac{\pi}{p}\right)^{\frac{1}{2}}=\frac{v(M+1)}{6823\ \Delta^{\frac{1}{12}}M} \text{ or } \pi=\left[\frac{v(M+1)}{6823\ \Delta^{\frac{1}{12}}M}\right]^2\times p.$$

The logarithmic work now follows:

27		log 1.43136
2240		log 3.35025
$g=32.155$ (at proving ground)		log 1.50725
$A=(3.1416\times 36)$ 3.1416		log .49715
sq. in. 36		log 1.55630
$u=42.25$ feet		log 1.62583
$P_{max}=15.18$ tons		log 1.18127
4	log .60206	colog 9.39794−10
$p=870$ lb.	log 2.93952	colog 7.06048−10
$k=$		
$v=2900$ feet per second	log 3.46240	
	2 log 6.92480	colog 3.07520−10
$\frac{K}{v^2}=4.8198$		log .68303

① $2-\left(\frac{K}{v^2}\right)=-2.8198$ log (−) .45022   2 log .90044

$\left(2-\frac{K}{v^2}\right)=$ 7.9513

subtract 4

3.9514 log .59675 $\frac{1}{2}$ log .29838

②1.9878

②−①=4.8076

$\frac{1}{2}$ [②−①]=2.4038=M

3.4038=$M+1$

With these values solve next for ω as follows:

$V=2900$ foot-seconds   log 3.46240

$M+1=3.4038$ log .53196

6823   log 3.83398   colog 6.16602−10

$\triangle=.65$ log 9.81291−10 $\frac{1}{12}$ log 9.98441−10   colog .07559

$M=2.4038$ log .38089   colog 9.61911−10

9.79508−10

2

9.59016−10

$p=870$ lbs.   log 2.93952

$\omega=338.5$ lbs.   log 2.52968

b. Having thus obtained ω: from the equation

$\triangle=\frac{\omega\times 27.68}{S}$, a value of S is determined.

$\triangle=.65$ log 9.812910−10   colog .18709

$\omega=338.5$ log 2.52968

27.68   log 1.44217

$S=14419$ cubic inches   log 4.15894

c. Taking 93 inches as the length of the powder chamber, the diameter and its chambrage is found.

$$S=\frac{\pi D^2}{4}\times 93 \text{ or } D=\sqrt{\frac{14.419\times 4}{93\times 3.1416}}$$

14419   log 4.15894

4   log .60206

3.1416 log .49715   colog 9.50285

93 log 1.96848   colog 8.03152

2) 2.29537

$D=14$ inches   log 1.14769

d. The next step is to determine a value of β from formula V, in this manner:

$\beta=\frac{b}{\left(1-\frac{\triangle}{\delta}\right)\left(\frac{S}{p}\right)^{\frac{2}{3}}}$. $b=\frac{u}{M}$ u=42.25   log 1.62583

M=2.4038 colog 9.61911

$\triangle=.65$ log 9.81291

$\delta=1.55$ log .19033

$\frac{\triangle}{\delta}$=.41935 log 9.62258

$1-\frac{\triangle}{\delta}$=0.58065 log 9.76392 . . . . .colog .23608

S=14419 log 4.15899
p=   870 log 2.93952

$\frac{S}{p}$ log 1.21942 $\frac{2}{3}$ log .81295 .colog 9.18705

β=4.6566 . . . . .log .66807

e. Having secured the foregoing results and seeing that they are within reason, the gun can be laid out along these lines. Then the gun may be altered in various dimensions for various reasons. If this is done, new calculations must be made.

To construct the pressure curves, "u" as determined was 42.25 feet. Select five points to use. Take 3, 8, 15, 24, and 36 feet. Since M=2.4038=$\frac{u}{b}$, b=17.6,

$$a=\frac{2900}{M}(M+1)=\frac{2900\times3.4038}{2.4038}=4106.5$$

Using $v=\frac{a\,u}{b+u}$, the velocity curve is calculated.

	$u_1=3$	$u_2=8$	$u_3=15$	$u_4=24$	$u_5=36$
	$b+u_1=20.6$	$b+u_2=25.6$	$b+u_3=32.6$	$b+u_4=41.6$	$b+u_5=53.6$
log=	1.31387	log= 1.40824	log= 1.51322	log= 1.61909	log= 1.72916
colog	8.68613	8.59176	8.48678	8.38091	8.27084
a log	3.61347	3.61347	3.61347	3.61347	3.61347
u log	.47712	.90309	1.17609	1.38021	1.55630
	2.77672	3.10832	3.27634	3.37459	3.44061
	v_1=598 f. s.	v_2=1283 f. s.	v_3=1889 f. s.	v_4=2369 f. s.	v_5=2758 f. s.

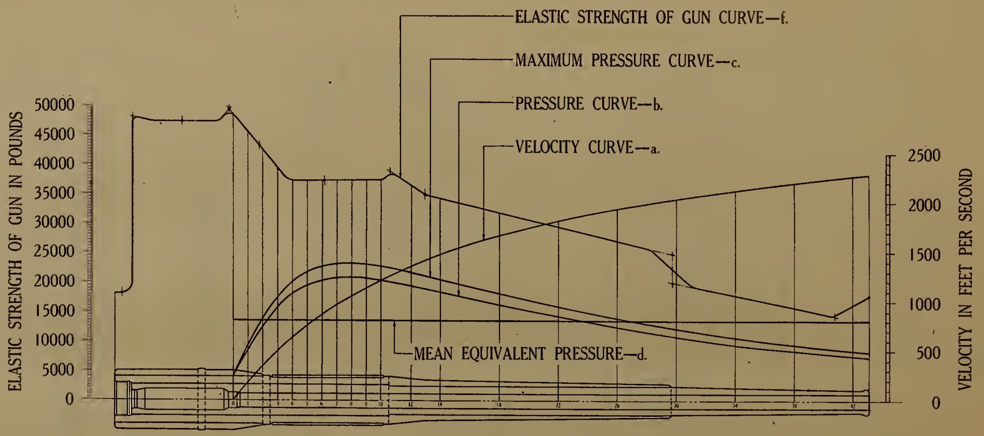
With these points the velocity curve may be drawn.

The next step is to determine the pressures at these points.

$$R=\frac{P_{(\text{max. gauge})}\times\left(\frac{3\,b}{2}\right)^3}{\frac{b}{2}}=\frac{15.18\times\left(\frac{3\times17.6}{2}\right)^3}{\frac{17.6}{2}}\text{ or}=\frac{15.18\times\overline{26.4}^3}{8.8}$$

15.18 log   log 1.18127
26.4 log 1.42160   log 4.26480
8.8 log .94448 colog 9.05552

R= . . . . .log 4.50159. **The formula $P=\frac{R\times u}{(b+u)^3}$ is next used.**



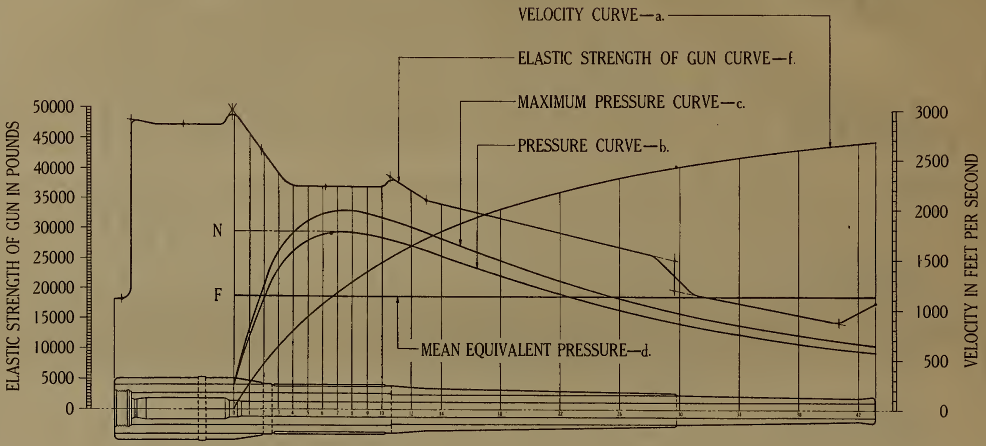
5-INCH 50 CALIBER GUN.

CAPACITY OF POWDER CHAMBER	1200 CU. INS.
WEIGHT OF CHARGE	15 LBS.
WEIGHT OF PROJECTILE	60 LBS.
TRAVEL OF PROJECTILE	215.6 INS.
MUZZLE VELOCITY	2300 F. S.

DATA.

VELOCITY CURVE, I. V. 2300 F. S.	a.
PRESSURE CURVE, ENERGY OF THE PROJECTILE	b.
CURVE OF MAXIMUM PRESSURE b x 1.12	c.
MEAN EQUIVALENT PRESSURE	d.
CURVE OF ELASTIC STRENGTH OF THE GUN	f.

5-inch 50 Caliber Gun Curves, Muzzle Velocity 2,300 Foot-Seconds.



5-INCH 50 CALIBER GUN.

CAPACITY OF POWDER CHAMBER	1200 CU. INS.
WEIGHT OF CHARGE	19.2 LBS.
WEIGHT OF PROJECTILE	60 LBS.
TRAVEL OF PROJECTILE	215.6 INS.
MUZZLE VELOCITY	2700 F. S.

DATA.

VELOCITY CURVE, I. V. 2700 F. S.	a.
PRESSURE CURVE, ENERGY OF THE PROJECTILE	b.
CURVE OF MAXIMUM PRESSURE b x 1.12	c.
MEAN EQUIVALENT PRESSURE	d.
CURVE OF ELASTIC STRENGTH OF THE GUN	f.

5-inch 50 Caliber Gun Curves, Muzzle Velocity 2,700 Foot-seconds.

$u_1=3$	$u_2=8$	$u_3=15$	$u_4=24$	$u_5=36$
$b+u_1=20.6$	$b+u_2=25.6$	$b+u_3=32.6$	$b+u_4=41.6$	$b+u_5=53.6$
log=1.31387	log=1.40824	log=1.51322	log=1.61909	log=1.72716
3 log=3.94161	3 log=4.22472	3 log=4.53966	3 log=4.85727	5.18748
colog=6.05839	5.77528	5.46034	5.14273	4.81252
R log 4.50159	4.50159	4.50159	4.50159	4.50159
u log .47712	.90309	1.17609	1.38021	1.55630
log 1.03710	1.17996	1.13802	1.02453	.87041
$P_1=10.9$ tons	$P_2=15.1$ tons	$P_3=13.7$ tons	$P_4=10.6$ tons	$P_5=7.4$ tons

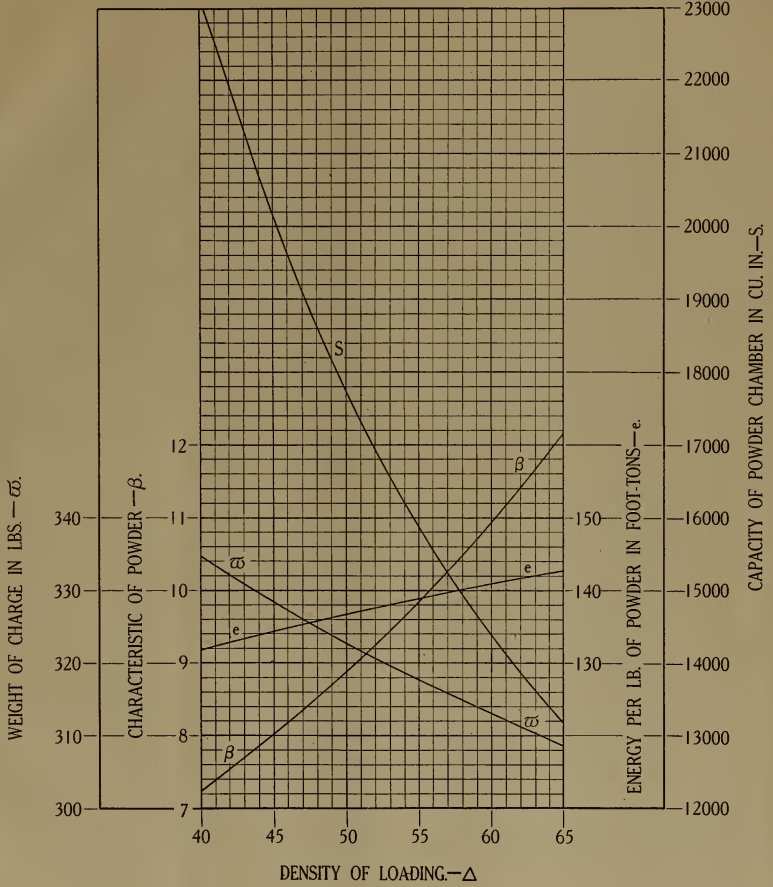
Multiply the pressures by 1.4 and the values of the ordinates for the minimum strength curve are obtained.

Thus the three curves necessary before the finished design of the gun is adopted are found. They are shown in Plate 50.

A more complete sketch, showing the gun and the curves therefor, is given for the 5-inch 50 gun, with muzzle velocity of 2,300 foot-seconds, in Plate 51.

Plate 52 shows the curves for M. V, 2,700 foot-seconds for this gun. It is evident that the curves of pressure lie too close to the curve of gun strength and the factor of safety is too low. At $u=7$ the factor is found to be 1.12; at $u=32$, 1.23: and at $u=41$, 1.26. The factor of safety is too small at the breech, at the chase, and at the muzzle; consequently the powder is not suitable to the gun; or, more exactly, the gun is not suitable for such a velocity, because neither change in the charge nor in the characteristic of the powder could bring the factor of safety to the proper figure throughout. A smaller charge of a quicker powder would lower the pressure at the muzzle and increase the factor of safety at that point, but at the same time would raise the pressure at the breech and reduce there the factor, which is already too small. A large charge of a slower powder would reduce the pressure at the breech but would increase it at the muzzle, hence the gun is really not suitable for such a velocity. The standard velocity for this gun is 2,300 foot-seconds, with resulting curves as shown in Plate 51.

From these few examples, the value of the science of interior ballistics may readily be understood. No formulas save the elementary ones have been given. These formulas, by use of various transpositions, will give a close approximation to other points than those treated here which may arise in connection with gun design and with the general problem of the action of the forces in the gun. The subject of mount design has not been touched upon, for instance, yet the following procedure may be outlined as an evidence of the adaptability of the formulas. From the velocity curve of the projectile the acceleration at any point can be obtained, and from this the forces acting to produce the recoil of the gun, and, knowing these forces, the recoil system and the mount may be designed.



12-INCH, 45 CALIBER GUN.

Graphs for Gun Elements.

Chapter XXI.

EROSION.

1. On discharge of a gun the powder is suddenly converted into gas at a very high temperature with the attendant high pressures. This change results in several undesirable effects. If steel is heated to a high temperature and suddenly cooled, it will be hardened and this hardening will be more pronounced with high-carbon steels. At each discharge of a gun a thin film of steel in the bore is heated and then suddenly cooled, the rate of cooling being accelerated by the cold metal of the tube. It is found that after a few rounds the bore becomes quite hard, sufficient to resist the ordinary tools used in manufacture. If the metal of the bore absorbs carbon, the additional carbon would assist in making the steel harder.

Cause of erosion.

2. An examination of the bore after a number of rounds have been fired discloses a network of fine cracks covering the chamber in the vicinity of the compression slope and extending down the bore. These cracks are heat cracks and are found in closed bombs as well as in guns. Various explanations have been offered to account for them. The hardening of the metal sets up surface strains, as well as making the metal more brittle, and in this condition it is liable to crack when subjected to high pressures. If the metal had been superficially carbonized by the action of the gas, these conditions are exaggerated.

Appearance of steel in bore.

3. The strains which exist in the metal of the bore are caused by a thin layer of heated metal expanding against metal relatively colder. The physical change in the metal of the bore assists in generating heat cracks. The physical characteristics of the steel over a thin film are changed by firing, the metal becoming much harder, with consequent reduction in ductility and elongation and increase of brittleness. In such a hard state steel will rupture quickly where there are any sharp changes of direction in its surface; consequently it is to be expected that heat cracks will be more pronounced at the angles at the bottom of the rifling grooves. The following explanation is given for heat cracks: At each discharge of the gun the surface metal is heated to a temperature that would cause it, if free, to expand much more than it can stretch within the elastic limit. The free expansion is prevented by the cold outer metal and the heated metal is crushed. When it cools it is held in a state of tension by the outer metal, and as the surface assumes more and more a state of circumferential tension, it finally yields and develops cracks, usually longitudinally.

Heat cracks.

4. Heat cracks weaken the tube, but to an extent not determined. They are not considered serious in built-up guns and their presence is not a serious menace to the strength of guns.

Effect of heat cracks.

Elements affecting erosion.

5. Erosion is the wearing away of the metal in the bore by continued firing. It is casued by the rush of gases over the heated film of metal. To produce erosion, high heat and motion of the gases are required. That heat is necessary is obvious; that motion is required is seen from bomb experiments. The friction of the moving gases cause the washing away of the eroded metal assisted by the friction of the band. The elements controlling erosion are the temperature, the velocity of the gases, and the time.

Heat of combustion.

6. The temperatures of combustion of nitrocellulose are about 2,000° F. and for nitroglycerine powders 2,800° F. The melting point of gun steel is about 2,650° F., and its friable point is much lower. This temperature is reached very quickly, and the rate is greatly in excess of the possible rate the steel can carry off the heat by conduction. Therefore it is easy to see how a thin film is quickly brought to the friable state. The quantity of heat is closely associated with the temperature, for the temperature of the metal will increase with an increase in the heat available so that the weight of charge affects the erosion.

7. The increase in heat also causes an increase in pressure, with resulting increase in activity of the gases—i. e., the velocity, energy, and quantity of gas. Increase in pressure also brings with it a more rapid burning, hence quicker delivery of the heat, in the charge.

8. The time of travel varies with the length of the gun. The time it takes for building up the forcing pressure and for starting the projectile and moving at the first caliber distance down the bore also varies with the caliber. The longer the temperature is maintained and the gases rush over the heated metal the greater will be the erosive effect. The time taken for a projectile to travel 1 caliber distance down the bore is one-half of the total time of travel in the bore.

9. Erosion will then occur with the high temperatures and high velocities. This is shown by the fact that erosion occurs at the origin of the rifling and to a lesser extent at the muzzle. It is also to be expected to be greater in large caliber guns, as the weight of charge increases as the cube of the caliber and the surface for absorbing heat as the square, in addition to the fact that time of the action of the gases is also greater.

10. The disadvantage of erosion lies in the enlargement of the bore resulting in reduction in pressure and velocity until a point is reached where the projectile will not get the proper rotational speed and will then give very inaccurate flight. The life of a gun is the number of rounds which can be fired from it before it loses its accuracy. The loss from weakening is so inappreciable that were it not for the wearing away of the rifling the life would be indefinite. The general policy is to withdraw guns from service for relining after a fixed number of rounds. While a gun when withdrawn might fire more rounds accurately and not show signs of dispersion, it could not fire a full allowance with safety.

11. Erosion may be measured by change in projectile seating, enlargement of the bore, or by the loss in muzzle velocity. The first two are not suitable for service conditions, but are always measured at the proving grounds. As the material effect is in the reduction in velocity, and as it is necessary to know this reduction for rounds fired, curves for each caliber and mark of gun are provided showing the loss to be expected for any number of equivalent rounds fired. The equivalent rounds fired are used since the erosive effect is a function of the weight of charge. The curves used are made up from actual firings at the proving ground. To obtain the equivalent rounds fired, the equation

$A=\left(\frac{\bar{w}_1}{\bar{w}}\right)$ 19/4 where $\bar{w}=$ the standard weight of charge for service velocity and $\bar{w}_1$ equals the charge used. This gives the proportional effect of a round compared with that of a service round, which is considered as 1. Reduced charges have a value of about one-fourth of a service round when computing the erosion correction, and the special spotting charges for 1,700 foot-seconds have about one-tenth of the value of the service round.

12. For more complete details of erosion, consult Ordnance Pamphlet No. 412.

Chapter XXII.

DISPERSION.

1. Every mechanic should know the accuracy and limitations of his tools. As was stated in the previous chapter, the artillerist and designer come together on the common ground of muzzle velocity and true flight of the projectile. When the projectile leaves the muzzle of the gun, no further control over it is possible, so that conditions which will prevent it finding the desired mark must be anticipated and corrected in advance. Errors in flight may be grouped as follows:

(*a*) Range errors and lateral errors.

(*b*) Dispersion errors both vertical and lateral.

It is convenient to call the former "fire-control errors" as their values are dependent largely on fire control. Even if it were possible to have no dispersion, there may always be fire-control errors, which, regardless of dispersion errors, must be kept as small as possible to insure the maximum hitting. This phase of accuracy of fire is under control of the operating personnel and is beyond the efforts of the gun designer and does not come within the scope of this manual.

Causes.

2. Dispersion errors will always exist to some degree, as production of materials must allow for some manufacturing tolerances. The principal causes of dispersion are:

(*a*) Inaccuracies in design.

(*b*) Variations in the powder, projectile, cartridge case, primer, etc.

(*c*) Variations in the gun.

(*d*) Variations in sight and mounting.

(*e*) Personal errors in handling material.

3. New ordnance material is always tested before issue or installation and every endeavor is made by thorough experimental work to eliminate all causes of inaccuracies. The final design is approved and manufacture started only when the efficiency of the material has been demonstrated. Furthermore, research is habitually being prosecuted for the improvement of known designs, as the ever-changing conditions in service demand further advances in the art. Where errors in dispersion can be traced directly to the design, there is immediately the necessity for further experiments in the endeavor to correct the design. However, there are many other possible reasons for causing dispersion which must be investigated first.

Errors in dispersion.

4. Errors in dispersion due to the powder charge may be one of the following:

(1) Variation in weight of charge.

(2) Variation in temperature of powder.

(3) Variation in density of loading.
(4) Hygroscopic condition of powder.
(5) Variation in age of powder.
(6) Imperfect blending.
(7) Variation in indexes.
(8) Variation in weight distribution of ignition charge.
(9) Variation in form of charge.
(10) Unsuitability of powder.
(11) Variation in loading.
(12) Variation in physical firing interval.
(13) Variation in muzzle velocities.

5. A variation in the weight of charge may occasion a large variation in pressure, giving a large error in muzzle velocity. Great care is taken in establishing the correct weight of charges assigned to the various guns. As may be seen from the chapter on "Assembly of Ammunition" especial care is taken at the ammunition depots in assembling the weight of charge correctly. The serious effects of assembling the wrong index or using the wrong weight of charge in the possibilities of creating excessive pressures is fully appreciated. Time and again reports of excessive or deficient velocities have been received and check firings conducted and in only one case on record has an ammunition depot erred in the weight of charge. This remarkable record certainly shows that in case of errors, particularly in range, that the cause should be looked for elsewhere in the system.

6. A temperature of 90° F. has been selected as the uniform temperature for proof of powders and for fixing the charge, as this closely approximates that found in the magazines on board ship. A change in the temperature of the powder, however, will cause a change in the pressure and velocity. The values of the changes in velocity have been determined experimentally at the proving ground and it was found that a change of 1° F. from 90° F. will cause a change of about 2 foot-seconds in velocity. The variations in temperatures in magazines is discussed in the chapter on "Stowage," and from this it is readily seen how important it is to keep the magazines uniform, to know what the temperatures are and to correct for variations accordingly. Suppose one turret magazine is 10° F. hotter than another, a round fired from the former in a 12-inch 2,700 foot-seconds gun at 10,000 yards would without correction have a plus vertical error over one fired from the latter of 35 feet, and the result in a salvo would be an excessively large pattern. It must be borne in mind that it is the temperature of the powder which causes the variation, so that it is important not only that the magazine but that the powder itself be uniform.

7. In general an increase in the density of loading causes an increase in the pressure with a resulting increase in the velocity. With the projectile properly seated and the correct weight of powder charge, the density of loading is constant and should occasion no error. The ratio of the density of loading to the weight of charge is a constant for any caliber and mark of gun, though it varies for the different calibers, as $\frac{\Delta}{w}=\frac{27.65}{S}$. No error is introduced, therefore, by using different indexes, as this ratio is established by the proof of the powder. The density of loading is changed in the individual gun by the effects of erosion, as the projectile may seat farther down the bore as the metal at the origin of the rifling is melted away. The band lip, however, is designed to prevent this, and also to bit in and prevent the projectile slipping back and reducing the size of the chamber and increasing the density of loading. Overramming or dropping back of the projectile are the only conditions affecting the density of loading within the control of the personnel afloat, as the design value is fixed in the design of chamber and powder.

8. As was seen in the chapter on "Smokeless powder and assembly of ammunition," powder is packed at the factory under standard atmospheric conditions, and is assembled at the depots under the same conditions and is always kept in air-tight containers. If equal care is taken aboard ship to keep the powder in air-tight containers and to remove it therefrom just prior to firing, no difficulty will be experienced due to variations in the hygroscopic conditions. If some tanks leak, however, dispersion will result from irregular muzzle velocities as the charges exposed to dampness will become slower.

9. As powder ages it generally loses some of its volatiles, becoming quicker, giving slightly higher pressures and velocities. If the conditions throughout an index has been the same, the change in velocity would be uniform, hence will cause a range error and not an error in dispersion. If, however, some charges are permitted to lose volatiles faster than others, the results obtained will be irregular. No error is introduced by aging powder aboard ship if it proceeds uniformly, and provided the powder passes satisfactory tests, although the pressures and velocities may differ from those obtained on proof. Variations due to deterioration will not slow up until the advance stages long after the powder is rendered unfit for use in service. It is generally estimated that the life of a stabilized powder is 20 years, but this is varied by stowage condition. Keeping the powder tanks tight lengthens the life of a powder.

10. Variations due to imperfect blends do not occur as the requirements of the powder specifications require blending and regularity of performance. Small lots of similar nitration and volatiles are blended to make up an index before proof firing. The blending process gives very uniform results, as the lots composing the blend vary very little chemically and physically. Should lots varying widely be used to make up a blend, irregular ballistic results might be expected, but these conditions do not obtain in service.

11. The size of an index is fixed by the physical requirements for its manufacture and blending, and as a result several different indexes of large caliber powders are required to make up the allowance for a ship. Also the conditions of storage, the age of the powder, etc., will affect the velocity, so that firing different indexes in a salvo may result in dispersion. Indexes have different weights of charge assigned due to slight differences in manufacture and may be proved at different times so that errors may thus creep in. These should, however, not exceed one-half of 1 per cent. The present methods of proof of powders takes account of difference in proof conditions, however, in order to reduce the possibility of irregular results being obtained. An index should be fired in all guns in a salvo until expended and then another index used, the same one for all guns. This requires an equal distribution of each index among the different turrets. It is most desirable to have only one index aboard ship, and due to changes in the methods of blending this will be done with future powders.

12. The present methods of assembling ignition charges, both as to shape, size, and arrangement, have been devised after considerable experimental work, and standards are fixed for each size of gun. About the only possibilities of causing errors aboard ship is in ripping a charge and losing some of the ignition (a very dangerous proceeding, as the black powder is readily fired by friction) or by inverting a bag. Care, therefore, should always be taken to load with the red end of each section toward the breech.

13. No variation afloat occurs from this cause as the powder is prepared in standard form. Results obtained from firings at the proving ground showed that change occurred by changing the number of bags in a charge, provided sufficient ignition charge was present. However, the extreme case of firing a charge placed loosely in the bore showed high pressures compared with a packed charge; consequently, to avoid variations and for more convenience in loading, loose bags should be laced tightly.

14. It has been found by experiment that varying the position of the powder sections in a gun will cause a variation in pressure and velocity. The charge should be always placed in the same relative position in the chamber to prevent variations. The present design of powder charges allows at the minimum a clear space of 4 inches in the dimension of the axis of the bore and will usually be slightly over, due to the necessity of arranging the powders in stacked charges. Variations in weights of charge are taken up in the diameter of the sections.

15. The physical firing interval may be taken as the time from the closing of the firing circuit until the ejection of the projectile from the muzzle. It is made up of the interval for primer action, interval for the powder to generate sufficient pressure to cause relative motion between the gun and projectile, travel interval or time for projectile to traverse the bore. Investigations have shown that variations in these intervals have no material effect on the dispersions, being of the order of 0.05 hundredths of a second. This variation, however, is appreciable and developments toward its elimination are progressing.

Speed of primers.

16. Variations are found to exist in muzzle velocities even though all conditions are made as nearly perfect as they can be. The variations found are due to the summation of the many errors due to powder, projectile, bands, etc. The requirements for serviceable material is that the variation shall be less than one half of 1 per cent.

17. There is evidence that there is a difference in the speed of primers. From tests conducted, the percussion primer is much faster than the electric primer, but other conditions require the use of the latter. Considering the total firing interval, the primer intervals, however, are relatively small and less when the firing circuits are properly arranged for salvo firing. The total firing interval may be taken as the time from the instant the pointer or director operator wills to fire until the projectiles leave the bore. This interval may be divided as follows:

(*a*) Time from instant when pointer wills to fire until closing of the key has been completed.

(*b*) Physical firing interval mentioned above.

The average time for (*a*) of five pointers, as measured at the proving ground, gave 0.179 second, varying from 0.138 to 0.236 second. This personal interval varies greatly. The interval included in (*b*) is of the order of 0.08 to 0.15 second for a 14-inch gun; thus the combined intervals average about 0.29 second. Attention to firing circuits, generators, transformers, when firing full gun salvos, should present the physical firing interval exceeding the value given herein.

Variation of projectiles.

18. The following variations in projectiles may affect dispersion:

(*a*) Variations in weight.
(*b*) Variations in bourrelet.
(*c*) Variations in rotating bands.
(*d*) Variable form of projectile.
(*e*) Position of the center of gravity.

(*a*) The error introduced by firing projectiles of different weights is not very great for small variations. The tolerances are made very close in order to eliminate any such variation. The completed weight of a projectile includes the burster charge and fuse.

(*b*) (*c*) One function of the bourrelet and band is to center the projectile in the bore and cause it to traverse the bore without variation. Assuming an exaggerated condition, suppose a projectile has a very small bourrelet and is centered fairly well by the band. As the band engraves and rotates the projectile the point will oscillate and result in erratic flight. The bourrelet clearance is 0.015 inch, and is measured to vary close tolerance by gauges. Rotating bands also are carefully measured. Care should be exercised that paint is not applied to bourrelet or that either bands or bourrelets are reduced by rubbing with emery cloth. Bourrelets are required to be kept coated with vaseline. Since the bourrelet design has been adopted fully a 5 per cent reduction in coefficient of form has resulted. In addition to this effect, increase in size of rotating bands, either in width, thickness, or form, causing increased forcing and a resulting increase in pressure and velocity. For service conditions variations due to the latter cause are slight due to careful measurement of tolerances. Experiments have shown that considerable dispersion is caused by the wobbling of the projectile due to noncentering. The bourrelet dimension can not be made too large, else slight bore restrictions would render firing dangerous. The French report excellent results with double-banded projectiles, the front band being larger than the usual bourrelet dimension and susceptible of some forcing in case of a restriction.

(*d*) The form of a projectile is of great importance. The outside contour of all the projectiles fired in a salvo should be the same and the fire control take cognizance of the form, for the length of projectile and length of the ogival has an important effect on the range. The shape of the band is also involved, as the copper may be so displaced as to form fringes, which exert a rudderlike effect on a projectile.

(*e*) Varying the position of the center of gravity will cause variation in range. However, tests are applied to detect, this and the slight variation permitted in manufacture is too small to cause any appreciable variation in range.

19. All these variations are such as occur in manufacture and design and are without the scope of the personnel afloat. They are mentioned here in order that a more complete knowledge of the causes of variation may be had. More complete data may be found in Ordnance Pamphlet No. 409.

Chapter XXIII.

AMMUNITION REPORTS.

Importance of reports.

1. The importance of keeping proper records of ammunition can not be overestimated. Records warn of bad methods, unwise procedure, and inefficient operation. Immediate, reliable, and adequate records give information which impels to prompt and vigorous action. Records measure progress and show direction; they furnish a basis for future work. "A record is anything that gives information of any kind." The bureau records for ammunition are based on reports; hence faulty reports result in faulty records in the bureau.

Number of reports.

2. The distribution and assignment of ammunition is handled in the Bureau of Ordnance, and all questions regarding its transfer for use must be referred to that bureau, except as authorized in Bureau of Ordnance circular letter No. A1B of 18 June, 1920. Sufficient information is required by the bureau so that the location, condition, and stability of all powder may be known at all times. This requires that ships and stations furnish the necessary information in the reports called for by the regulations. There are only four ammunition reports required, namely:

(*a*) Form 41, powder card, for service ammunition. Form 41–A, powder card, for target practice ammunition.

(*b*) Form 42, projectile card, for service ammunition. Form 42–A, projectile card, for target practice ammunition.

(*c*) Form 67, powder test card, for service ammunition. Form 67 (*a*), powder test card, for target practice ammunition.

(*d*) Form 71(*a*), expenditure card for service. Form 71(*b*), expenditure card for target practice.

3. The reports for service ammunition are salmon colored, and those for target practice ammunition are white, and they should be used for the purpose intended. Trial Board test ammunition is classed as T. P. Additional blank copies may be obtained from the Bureau of Ordnance upon request. The lack of the proper colored card should not delay the submission of a report at the proper time, as one of the same form of a different color may be used with a suitable notation in the heading.

4. The instructions on the backs of the cards should be carefully followed to avoid needless work in returning the cards for correction. The records in the bureau show what each ship and station was issued in the way of ammunition, and when reports are received, they are checked against this record to locate discrepancies, irregularities, shortages, etc. When shortages are noted or when the wrong ammunition is found to be on board a ship, steps to correct the situation are taken in the bureau. The reports are to be submitted annually on July 1, and thereafter when changes occur. This means that once each year a complete check is made on the ammunition afloat. At other times, when changes occur, they are reported at once, and appropriate action taken. If a ship, on July 1, has no target practice ammunition on board, cards are submitted with a notation "none on board." It is to be noted that reports are submitted by ships having ammunition allowances whether there is any on board or not. If on August 1, ammunition for S. R. D. P., S. R. B. P., and night T. D. Practice is received, cards showing this receipt must be submitted at once, giving the correct details called for on the report. If on September 1, S. R. D. P. is held, a card should be submitted showing the ammunition expended, and so on throughout the year. Many reports are received which are worthless, but practically all would fulfill their requirements were the instructions carried out.

5. Sample copies, printed below, show how the cards should be filled out. When describing any article by its mark and modification use a roman numeral for the mark and an Arabic numeral for the modification; as Mark VII, Mod. 3. The powder and projectile reports are self-explanatory, but care should be taken not to mix the target practice and service ammunition on the same report. The information required is to be obtained from actual inventory, not from previous reports. When filling out the powder-test card, it must be noted that only the tests completed during the month should be entered. When a surveillance test has been *completed* during the month, enter in the "Remarks" column the date the test was *completed*, and do *not again* report the results of this same test thereafter. Completion of a surveillance test means the number of days until fumes develop. When a surveillance test runs over a month, do not report it as a completed test until fumes have developed or 60 days have elapsed. Ships frequently report the results of tests forwarded by ammunition depots with shipment of ammunition. Such reports result in duplication in the bureau records, as they are listed when reported by ammunition depots. The date of completion of the test is important, for at a definite period thereafter, in accordance with the length of the test, the bureau looks for another report. Cases have occurred where ships have failed to carry out surveillance tests for periods as long as two years.

6. The expenditure card Form 70 (*a*) and (*b*) shall be submitted once each year on July 1, and shall show the money values of ammunition expended for USE. This card is not to be confused with the powder and projectile cards as far as expenditures are reported, but shall show the money values of all expenditures previously reported throughout the year on the powder and projectile cards. The data on the expenditure cards 70 (*a*) and (*b*) form the basis for a report showing the cost of ammunition expended for the Navy in each fiscal year for the information of Congress. These reports should not be confused with the reports required to be submitted by gunnery officers to the Bureau of Supplies and Accounts.

7. A check-off list of ships and stations is kept in the bureau and as the reports are received the various ships and stations are credited with them, and notices mailed to those who fail to submit reports within one month of the date due.

8. Reports are frequently received in the bureau that ships and stations can not submit reports as they have failed to receive invoices for the material received. Existing instructions issued by the Bureau of Supplies and Accounts require that a priced invoice shall accompany an issue of material, and summaries with invoices attached will be forwarded later by the property accounting officer. Ammunition depots should see that the priced invoice is furnished and that complete information regarding the ammunition is supplied the ship, so that information will be available for preparing reports.

9. The following circular letter is included herewith as a permanent record:

CIRCULAR LETTER NO. A-27 OF FEBRUARY 17, 1921.

To: All bureaus, ships, and stations.
Subject: Reports of ammunition to Bureau of Ordnance.
Inclosure (herewith): (A) Eight sample forms of ammunition reports.
(B) Twenty copies of Buord Forms 41, 41 (*a*), 42, 42 (*a*), 67, 67 (*a*).
(C) Ten copies of Buord Form 70 (*a*), 70 (*b*).

1. The following instructions regarding submitting ammunition reports will be incorporated in Part IV of the Ordnance Manual, which is to be published in the near future. The subject matter is published herewith for the information of the service in advance of the issue of Part IV in order that commencing July 1, 1921, the new reports as required herein may be used.

"The distribution and assignment of ammunitions is handled in the Bureau of Ordnance and all questions regarding its transfer for use must be referred to that bureau, except as authorized in Bureau of Ordnance Circular Letter No. A–13, of June 18, 1920. Sufficient information is required by the bureau so that the location, condition, and stability of all powder may be known at all times. This requires that ships and stations furnish the necessary information in the reports called for by the regulations. There are only four ammunition reports required, namely:

"(*a*) Form 41, powder card, for service ammunition. Form 41 (*a*), powder card, for target practice ammunition.

"(*b*) Form 42, projectile card, for service ammunition. Form 42 (*a*), projectile card, for target practice ammunition.

"(*c*) Form 67, powder test card, for service ammunition. Form 67 (*a*), powder test card, for target practice ammunition.

"(*a*) Form 71 (*a*), expenditure card, for service. 71 (*b*), expenditure card, for target practice. Navy Regulations, 1920, chapter 54.

"The reports for service ammunition are salmon colored and those for target practice ammunition are white, and they should be used for the purpose intended. Trial board test ammunition is classed as target practice. Additional blank copies may be obtained from the Bureau of Ordnance upon request. The lack of the proper colored card should not delay the submission of a report at the proper time, as one of the same form of a different color may be used with a suitable notation in the heading.

"The instructions on the backs of the cards should be carefully followed to avoid needless work in returning the cards for correction. The records in the bureau show what each ship and station was issued in the way of ammunition, and when reports are received they are checked against this record to locate discrepancies, irregularities, shortages, etc. When shortages are noted or when the wrong ammunition is found to be on board a ship, steps to correct the situation are taken in the bureau. The reports are to be submitted annually on July 1st and thereafter when changes occur. This means that once each year a complete check is made on the ammunition afloat. At other times when changes occur they are reported at once, and appropriate action taken. If a ship on July 1st has no target practice ammunition on board, cards are submitted with a notation 'none on board.' It is to be noted that reports are submitted by ships having ammunition allowances whether there is any on board or not. If on August 1st ammunition for S. R. D. P., S. R. B. P., and night T. D. practice is received, cards showing this receipt must be submitted at once, giving the correct details called for on the report. If on September 1st S. R. D. P. is held, a card should be submitted showing the ammunition expended, and so on throughout the year. Many reports are received which are worthless, but practically all would fulfill their requirements were the instructions carried out.

"Sample copies, printed below, show how the cards should be filled out. When describing any article by its mark and modification, use a roman numeral for the mark and an Arabic numeral for the modification; as Mark VII, Mod. 3. The powder and projectile reports are self-explanatory, but care should be taken not to mix the target practice and service ammunition on the same report. The information required is to be obtained from actual inventory, not from previous reports. When filling out the powder test card, it must be noted that only the tests completed during the month should be entered. When a surveillance test has been *completed* during the month, enter in the remarks column the date the test was *completed.* Do *not again* report the results of this same test thereafter. Completion of a surveillance test means the number of days until fumes develop. When a surveillance test runs over a month, do not report it as a completed test until fumes have developed or sixty days have elapsed. Ships frequently report the results of tests forwarded by ammunition depots with shipments of ammunition. Such reports result in duplication in the bureau records, as they are listed when reported by ammunition depots. The date of completion of the test is important, for at a definite period thereafter, in accordance with the length of the test, the bureau looks for another report. Cases have occurred where ships have failed to carry out surveillance tests for periods as long as two years.

"The expenditure card, Forms 70 (*a*) and (*b*), shall be submitted once each year on July 1st, and shall show the money values of ammunition expended for *use*. This card is not to be confused with the powder and projectile cards as far as expenditures are reported, but shall show the money values of all expenditures previously reported throughout the year on the powder and projectile cards. The data on the expenditure cards 70 (*a*) and (*b*) form the basis for a report showing the cost of ammunition expended for the Navy in each fiscal year for the information of Congress. These reports should not be confused with the reports required to be submitted by gunnery officers to the Bureau of Supplies and Accounts.

"A check-off list of ships and stations is kept in the bureau, and as the reports are received the various ships and stations are credited with them and notices mailed to those who fail to submit reports within one month of the date due.

"Reports are frequently received in the bureau that ships and stations cannot submit reports as they have failed to receive invoices for the materials received. Existing instructions issued by the Bureau of Supplies and Accounts require that a priced invoice shall accompany an issue of material, and summaries with invoices attached will be forwarded later by the property accounting officer. Ammunition depots should see that the priced invoice is furnished and that complete information regarding the ammunition is supplied the ship, so that information will be available for preparing reports."

Signed.—CHAS. B. McVAY, Jr.,
Chief of Bureau.

NOTES ON RECORDS.

Reports.

"A record is anything that gives information of any kind.

Records annihilate time and space, bring back the past, and give us dependable glimpses into the future;

Records measure progress and show its direction;

Records warn of wrong methods, unwise procedure, and inefficient operations;

Records check against extremes;

Records show the way to short cuts;

Records locate wastes;

Records quickly tell the direction and rapidity of progress;

Immediate, reliable, and adequate records give information which impels to prompt and vigorous action;

Records furnish a basis for all future work * * *.

Time wasted is gone forever."

[Original printed on white paper.]

Ord. 67a.

SMOKELESS POWDER TEST CARD

Serial No. 11

HEAT, SURVEILLANCE, AND VIOLET PAPER TEST

TARGET PRACTICE AMMUNITION

U. S. S. ARKANSAS
(Ship or Station.)

For month ending Nov. 30, 1920.
(Date.)

Index No.	Caliber	Where Put Up	Duration of test			Remarks	Date to be expended
			Heat test (*Minutes*)	Surveillance (*Days*)	Violet paper (*Days*)		
1	2	3	4	5	6	7	8
SPR 824	**3″50**	**Mare Is.**	—	—	**77**	**Magazine sample. Less than three mos. on board.**	**Mar. 1921**
SPD 1075	**5″51**	**Mare Is.**	—	—	**77**	**Same**	**April 1921**
SPD 1081	**12″50**	**Mare Is.**	—	—	**85**	**Same**	**Mar. 1921**
SPD 1112	**3″50**	**Mare Is.**	—	—	**77**	**Same**	**Mar. 1921**
SPD 1181	**1-pdr**	**St. Juliens**	—	—	**13**	**Magazine sample. Violet paper changed Nov. 17, 1920. Duration 965 days.**	**For ex-caliber. Indefinite.**
SPDX 1500	**1-pdr**	**St. Juliens**	—	—	**13**	**Same**	**Same**
SPD 1854	**5″51**	**Mare Is.**	—	—	**85**	**Magazine sample. Less than 3 mos. on board.**	**Mar. 1921** **Mar. 1921**
SPD 1888	**5″51**	**Mare Is.**	—	—	**85**	**Same**	
SPD 2179	**12″50**	**Mare Is.**	—	—	**105**	**Same**	**Mar. 1921**
SPD 2181	**12″50**	**Mare Is.**	—	—	**105**	**Same**	**Mar. 1921**
SPD 2183	**12″50**	**Mare Is.**	—	**45**	**189**	**Magazine sample. Received May 15, 1920. Surveillance test completed Nov. 20, 1920.**	**Mar. 1921**

I HEREBY CERTIFY that all tests, examinations, and inspections prescribed by the Department's orders and regulations have been fully complied with during the period since the last report.

John Doe, Comdr. *U. S. N.*
(Officer in charge of test.)

(Do not add to the length of this card.)

28015—24——20

(287)

7. Column 7 should show an entry giving information for the identification of the samples tested, thus: "Bulk" (from bulk powder at ammunition depots); "Retained Sample" (from retained samples at ammunition depots); "Charge" (from broken down charge); "Replacement" (from replacement sample, issued with each index); "Magazine Sample" (from 8-oz. magazine sample, issued with each index).

8. Tests of powder will be conducted and reported in accordance with the detailed instructions contained in Ordnance Pamphlet No. 20 on "Service Explosives," until such time as this publication is superseded by the "Ordnance Manual, Part IV." The attention of all officers charged with the care, inspection, or tests of explosives is invited to these instructions.

9. When tests are conducted on another vessel or at an ammunition depot or other station, the vessel requesting the test should forward with samples three copies of this report, complete, except for heat and surveillance test entries. The vessel or station conducting the tests should fill in the information obtained on the completion of the tests, forwarding one copy of the report to the Bureau of Ordnance, one to the ship requesting the test, and retaining one for file.

10. This form is for target-practice ammunition only. Use N. Ord. 67 for service ammunition test reports.

11. Heat and surveillance tests are not required on target-practice powders which have been on board less than three months.

FOLD ON THIS LINE ONLY

N. Ord. 67a.

Serial No. ....

SMOKELESS POWDER TEST CARD

HEAT, SURVEILLANCE, AND VIOLET PAPER TEST

....
(Ship or Station.)

For month ending ....

APPROVED AND FORWARDED.

....

....

This space for Bureau's stamp.

INSTRUCTIONS

1. This report will be made by ships and ammunition depots to the Bureau of Ordnance at the end of each month and will include all tests completed during the month. Commanding officers of vessels of the Asiatic Fleet will make this report to the Naval Ammunition Depot, Olongapo, P. I., and will forward a copy to the Bureau of Ordnance.

2. Reports will be numbered serially, commencing a new series with each calendar year. Service and target practice will have different serial numbers.

3. Index numbers should be entered in column 1 in regular numerical sequence, prefixed with the proper powder designation, such as "S. P.," "S. P. R.," "S. P. D.," "S. P. D. X.," "S. P. D. B.," "S. P. D. W.".

4. Column 4 should have an entry made in it only when a heat test has been completed during the month, showing the number of minutes required to complete the test. The heat test is to be discontinued after forty minutes and an entry "40+" made.

5. Column 5 should have an entry made in it only when a surveillance test has been completed during the month, showing the number of days required to complete the test. The surveillance test is to be discontinued after 60 days and an entry of "60+" made.

6. Column 6 should be filled in showing the number of days the current violet paper test has been running, and should always be filled in when a heat or surveillance test is reported. The plus sign should not be used in reporting the violet paper test.

[Original printed on salmon colored paper.]

N. Ord. 67.—Rev.

SMOKELESS POWDER TEST CARD

Serial No....7...

HEAT, SURVEILLANCE, AND VIOLET PAPER TEST

SERVICE AMMUNITION

U. S. S. ARKANSAS
(Ship or Station.)

For month ending... August 31, 1921.
(Date.)

Index No.	Caliber	Where Put Up	Duration of Test			Remarks
			Heat Test (*Minutes*)	Surveillance (*Days*)	Violet Paper (*Days*)	
1	2	3	4	5	6	7
SP 736	3″50	Iona Is.	—	55	200	Replacement. Completed August 18 1921.
SPD 1008	5″51	Iona Is.	—	60+	605	Charge. Completed August 23, 1921.
SPD 1082	12″50	Iona Is.	—	60+	605	Same
SPD 1092	3″23	Iona Is.	—	60+	605	Same
SPD 1113	12″50	Iona Is.	—	60+	605	Same
SPD 1114	12″50	Iona Is.	—	60+	605	Same
SPD 1115	12″50	Iona Is.	—	60+	605	Same
SPD 1116	12″50	Iona Is.	—	60+	605	Same
SPD 1123	5″51	Iona Is.	—	60+	605	Same
SPD 1207	3″50	Iona Is.	—	60+	605	Same
SPD 1462	1-pdr	Iona Is.	—	47	605	Replacement. Completed Aug. 10, 1921.
SPD 1549	3″50	St. Juliens	—	60+	605	Charge. Completed Aug. 23, 1921.
SPD 1561	3″50	St. Juliens	—	60+	605	Same
SPD 1614	12″50	St. Juliens	—	60+	605	Same

I HEREBY CERTIFY that all tests, examinations, and inspections prescribed by the Department's orders and regulations have been fully complied with during the period since the last report.

(Do not add to the length of this card.)

John Doe, Comdr., *U. S. N.*
(Officer in charge of test.)

"Charge" (from broken down charge); "Replacement" (from replacement sample, issued with each index); "Magazine Sample" (from 8-oz. magazine sample, issued with each index).

8. Tests of powder will be conducted and reported in accordance with the detailed instructions contained in Ordnance Pamphlet No. 20 on "Service Explosives," until such time as this publication is superseded by the "Ordnance Manual, Part IV." The attention of all officers charged with the care, inspection, or tests of explosives is invited to these instructions.

9. When tests are conducted on another vessel or at an ammunition depot or other station, the vessel requesting the test should forward with samples three copies of this report, complete, except for heat and surveillance test entries. The vessel or station conducting the tests should fill in the information obtained on the completion of the tests, forwarding one copy of the report to the Bureau of Ordnance, one to the ship requesting the test, and retaining one for file.

10. This form is for service ammunition only. Use N. Ord. 67-a for target-practice ammunition test reports.

FOLD ON THIS LINE ONLY

N. Ord. 67.—(Rev.)

Serial No.........

SMOKELESS POWDER TEST CARD

HEAT, SURVEILLANCE, AND VIOLET PAPER TEST

....
(Ship or Station.)

For month ending ....

APPROVED AND FORWARDED.

....

....

This space for Bureau's stamp

INSTRUCTIONS

1. This report will be made by ships and ammunition depots to the Bureau of Ordnance at the end of each month and will include all tests completed during the month. Commanding officers of vessels of the Asiatic Fleet will make this report to the Naval Ammunition Depot, Olongapo, P. I., and will forward a copy to the Bureau of Ordnance.

2. Reports will be numbered serially, commencing a new series with each calendar year. Service and target practice will have different serial numbers.

3. Index numbers should be entered in column 1 in regular numerical sequence, prefixed with the proper powder designation, such as "S. P.," "S. P. R.," "S. P. D.," "S. P. D. X.," "S. P. D. B.," "S. P. D. W."

4. Column 4 should have an entry made in it only when a heat test has been completed during the month, showing the number of minutes required to complete the test. The heat test is to be discontinued after forty minutes and an entry "40+" made.

5. Column 5 should have an entry made in it only when a surveillance test has been completed during the month, showing the number of days required to complete the test. The surveillance test is to be discontinued after 60 days and an entry of "60+" made.

6. Column 6 should be filled in showing the number of days the current violet paper test has been running, and should always be filled in when a heat or surveillance test is reported. The plus sign should not be used in reporting the violet paper test.

7. Column 7 should show an entry giving information for the identification of the samples tested, thus: "Bulk" (from bulk powder at ammunition depots); "Retained Sample" (from retained samples at ammunition depots);

[Original printed on white paper.]

N. Ord. 41—A.

POWDER CARD.

Serial No. 4

TARGET-PRACTICE AMMUNITION. Annual return for July 1, 19

U. S. S. ARKANSAS, 21 Oct., 19 20
(Ship or station and date.)

Expended for
Transferred to
Received from N. A. D., Mare Island.
Cancel all except one showing reason for submitting card.

INDEX NUMBER.	KIND.	CHARGES.					Expended. Transferred. Received.	ON HAND AT DATE—		Ship's allowance.	Short of allowance.	GUN.	
		How assembled.	Priming cartridge case.	Kind of ignition.	Weight, pounds or grams.	Muzzle velocity.		Of index.	Of caliber.			Caliber and length.	Mark.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
				Target Practice Ammunition.									
					S. R. B. 1920–21								
2179	SPD	Chgs	—	Bk. C	228	2100	75	75	75	75	0	12/50	VII
					S. R. D. P. 1920–21								
2179	SPD	Chgs	—	Bk. C	228	2100	36	36	36	36	0	12/50	VII
1854	SPD	Chgs		Bk. C	16.2	2300	64	64	64	64	0	5/51	VIII
					Day Indiv. 1920–21								
1081	SPD	Chgs	—	Bk. C	330	2900	84	84	84	84	0	12/50	VII
					Division, 1920–21								
2181	SPD	Chgs	—	Bk. C	229	2100	96	96	96	96	0	12/50	VII
1888	SPD	Chgs	—	Bk. C	243	3150	80	80	80	80	0	5/51	VIII
				Day Torp. Def. 1920–21									
1075	SPD	Chgs		Bk. C	23.6	3150	160	160	160	160	0	5/51	VIII
				Experimental A. A. 1920–21									
1112	SPD	Shrap	C. P. I.	Primer	3.9	2700	40	40	40	40	0	3/50	X-2
				Gunnery Exercise and Ex-cal									
1500	SPDX	T	C. P.	Primer	68.5g	2000	2000	2000	2600	1200	0	1-pdr	V
				Trial Board and Testing.									
2179	SPD	Chgs	—	Bk. C	323	2900	60	60	60	60	0	12/50	VII

I HEREBY CERTIFY that the tests, examinations, and inspections prescribed by the Department's orders and regulations have been fully complied with during the period since the last report.

John Doe, Comdr., *U. S. N., Gunnery Officer.*

READ CAREFULLY INSTRUCTIONS ON BACK OF CARD.

with projectiles, use same nomenclature and designations as indicated in paragraph 8 of the instructions on back of projectile card (Form N. Ord. 42).

10. "Priming cartridge case" (column 4) will be designated: C. P., case percussion; C. P. I., case percussion ignition; C. C. I., case combination ignition.

11. "Kind of ignition" (column 5) will be designated: Bk. P., black prismatic; Bk. F., black fine grain; Bk. C., black cannon; Primer, when the ignition is contained entirely within the primer.

12. "Weight, pounds or grams" (column 6). Do not enter weight of charge for small arms.

13. "Muzzle velocity" (column 7) will not be entered for small-arms ammunition nor for saluting charges.

14. "Expended, Transferred, Received" (column 8) will show the quantity (number of rounds), expended, or transferred, or received. Cancel words not applying to the card as submitted. If desired both "transfer" and "receipt" may be reported on same card. If this is done (1) cancel "expended," (2) write across face of card "Transferred to ———," (3) make proper entries for transfer, (4) double space and write across face of card "Received from ———," (5) make proper entries for receipts. For annual returns make no entry in this column.

15. "On hand at date of index" (column 9) should show the *quantity* (number of rounds) on hand of the index number shown (on same horizontal line) in column 1. Do NOT ENTER THE INDEX OF THE POWDER IN THIS COLUMN.

16. "On hand at date, of caliber" (column 10) should show the quantity (number of rounds) on board of the caliber being reported. For example, if there are 300 6-inch charges of index 1180, and 100 6-inch charges of index 940, the proper entry in this column will be 400. Do NOT ENTER THE CALIBER OF THE GUN IN THIS COLUMN.

17. "Ship's allowance" (column 11) should agree with the latest orders for gunnery exercises. If not on allowance list enter "0" in this column.

18. "Short of allowance" (column 12) should show the difference between the amount on hand and the amount allowed. From these entries orders are issued to keep vessels' ammunition allowances filled. Requisitions for ammunition are not necessary (see Naval Instructions).

19. "Gun, Caliber and length" (column 13) will be designated 12/50 for 12-inch 50-cal. gun; 5/51 for 5-inch 51-cal. gun; 3″ F. G., for field gun; 3″ L. G., for landing gun; 6-pdr., for 6-pounder gun, etc.

20. "Gun, Mark" (column 14) will be designated: IX, for Mark 9; VII–2, for Mark 7, modification 2, etc.

21. Report all target-practice ammunition under heading (across face of card) "Target-practice ammunition—S. R. D. P., etc." (or whatever form of practice it is for), 1919–20.

22. Small-arms ammunition, primers, and superheater fuses (for torpedoes) should appear on powder card only, not necessary on projectile card.

FOLD ON THIS LINE ONLY.

N. Ord. 41—A. *Serial No.* ....

POWDER CARD.

U. S. S. ....
(Place and date.)

APPROVED AND FORWARDED:

...................., *U. S. N., Commanding.*

(This space for Bureau's stamp.)

INSTRUCTIONS.

1. Forwarded to Bureau of Ordnance direct:

(*a*) Annually, July 1, showing quantities on hand, allowances, shortages, and headed, "Annual returns for ———."

(*b*) When changes occur, showing quantities on hand, allowances, and shortages for only those calibers in which changes occurred. In case of "Transferred to," make note on face of card showing reason and authority for transfer.

2. To be submitted by:

(*a*) All vessels in commission that have target ammunition on board.

(*b*) Training stations and Marine Corps shore stations having target ammunition.

(*c*) Naval militia vessels and organizations having target ammunition.

3. When ammunition is transferred from a ship to another ship, or to a station, this card, properly filled out, will accompany the transfer (copy being sent to Bureau direct). Make entry on face of card showing reason and authority for transfer, as, "Remnants of target-practice ammunition, C-in-C letter ———."

4. In fixed ammunition the different "indexes" and "kinds" of powder will be on separate lines, and different "types of projectiles" assembled with the same index will be on separate lines.

5. Number reports serially, in upper right-hand corner. New series will begin with each calendar year, separate serial numbers will be used for target-practice ammunition.

6. This card should be made out from an actual inventory and not from an old return.

7. "Index No." (column 1) will be entered except in case of small-arms ammunition and black powder. This is the only column on the card in which the "Index No." of the powder should be entered.

8. The "kind" of powder (column 2) will be designated: S. P., smokeless; S. P. R., smokeless rosanaline; S. P. D., smokeless diphenylamine; S. P. D. W., smokeless diphenylamine reworked; B. P., brown prismatic; Bk. P., black prismatic; Bk. F., black fine grain; Bk. C., black cannon (coarse grain about the size of peas); Sal., saluting powder (black). Black powder for blanks for director salvos will be included in this report.

9. "How assembled" (column 3) will be designated: Sal., saluting charges; bulk, powder not made up in charges but carried in boxes or tanks; chgs., charges in bags or in cartridge cases without projectiles. For cartridges complete

[Original printed on salmon-colored paper.]

N. Ord. 41.

POWDER CARD.

Serial No. 1

SERVICE AMMUNITION.

Annual return for July 1, 19....

U. S. S. ARKANSAS, 1 July, 19 21
(Ship or station and date.)

Expended for ....
Transferred to ....
Received from ....
Cancel all except one showing reason for submitting card.

INDEX NUMBER.	KIND.	CHARGES.					Expended. Transferred. Received.	On Hand at Date—		Ship's allowance.	Short of allowance.	GUN.	
		How assembled.	Priming cartridge case.	Kind of ignition.	Weight, pounds or grams.	Muzzle velocity.		Of index.	Of caliber.			Caliber and length.	Mark.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1082	SPD	Chgs	—	Bk. C	334	2900	—	62					
1113	SPD	Chgs	—	BK C	324	2900	—	305					
1114	SPD	Chgs	—	Bk. C	323	2900	—	304					VII
1115	SPD	Chgs	—	Bk. C	320.5	2900	—	302	1302	1310	8	12/50	VII
1116	SPD	Chgs	—	Bk. C	313	2900	—	303					VII-3
1614	SPD	Chgs	—	Bk. c	326	2900	—	26					
1008	SPD	Chgs	—	Bk. C	23.0	3150	—	1738					
1123	SPD	Chgs	—	Bk. C	23.35	3150	—	2262	4400	4400	0	5/51	VIII
				Small Arms Ammunition									
		30 Cal. Ball Mod. 1906				—	—	—	320000	379200		59200	
		45 Cal. Ball C. A. P.			—	—	—	—	26000	26000		0	
		30 Cal. Ball Mod.1898			—	—	—	—	10000	10800		800	
		30 Cal. Blank Mod. 1898				—	—	—	10000	11000		1000	
		30 Cal. Dummy Mod. 1906				—	—	—	3000	1000		0	
		30 Cal. Blank Mod. 1909				—	—	—	10000	18000		8000	
		Superheater Fuses Mk. II, 1912					—	—	133	133		0	
		Black Powder		—	—	—	—	—	800			0	
		Lock Primers Mk. XV-1				—	—	—	17000	8640		0	
		Lock Test Primers			—	—	—	—	1500	2808		1308	
		C. P. Primers, Saluting,				—	—	—	800	1600		800	

I hereby certify that the tests, examinations, and inspections prescribed by the Department's orders and regulations have been fully complied with during the period since the last report.

John Doe, Comdr. ...., *U. S. N., Gunnery Officer.*

READ CAREFULLY INSTRUCTIONS ON BACK OF CARD.

with projectiles, use same nomenclature and designations as indicated in paragraph 8 of instructions on back of projectile card (Form N. Ord. 42).

10. "Priming cartridge case" (column 4) will be designated: C. P., case percussion; C. P. I., case percussion ignition; C. C. I., case combination ignition.

11. "Kind of ignition" (column 5) will be designated: Bk. P., black prismatic; Bk. F., black fine grain; Bk. C., black cannon; Primer, when the ignition is contained entirely within the primer.

12. "Weight, pounds or grams" (column 6). Do not enter weight of charge for small arms.

13. "Muzzle velocity" (column 7) will not be entered for small-arms ammunition nor for saluting charges.

14. "Expended, Transferred, Received" (column 8) will show the quantity (number of rounds), expended, or transferred, or received. Cancel words not applying to the card as submitted. If desired both "transfer" and "receipt" may be reported on same card. If this is done (1) cancel "expended," (2) write across face of card "Transferred to ———," (3) make proper entries for transfer, (4) double space and write across face of card "Received from ———," (5) make proper entries for receipts. For annual returns make no entry in this column.

15. "On hand at date of index" (column 9) should show the *quantity* (number of rounds) on hand of the index number shown (on same horizontal line) in column 1. DO NOT ENTER THE INDEX OF THE POWDER IN THIS COLUMN.

16. "On hand at date, of caliber" (column 10) should show the quantity (number of rounds) on board of the caliber being reported. For example, if there are 300 6-inch charges of index 1180, and 100 6-inch charges of index 940, the proper entry in this column will be 400. DO NOT ENTER THE CALIBER OF THE GUN IN THIS COLUMN.

17. "Ship's allowance" (column 11) should agree with the latest revisions to allowance lists. If not on allowance list enter "0" in this column.

18. "Short of allowance" (column 12) should show the difference between the amount on hand and the amount allowed. From these entries orders are issued to keep vessels' ammunition allowances filled. Requisitions for ammunition are not necessary (see Naval Instructions).

19. "Gun, Caliber and length" (column 13) will be designated 12/50 for 12-inch 50-cal. gun; 5/51 for 5-inch 51-cal. gun; 3″ F. G., for field gun; 3″ L. G., for landing gun; 6-pdr., for 6-pounder gun, etc.

20. "Gun, Mark" (column 14) will be designated: IX, for Mark 9; VII-2, for Mark 7, modification 2, etc.

21. Ammunition on hand or received for any other purpose than to fill service allowance should be so indicated under a self-explanatory heading, written across the face of the card. Always report target-practice ammunition on Form 41-a.

22. Small-arms ammunition, primers, and superheater fuses (for torpedoes) should appear on powder card only, not necessary on projectile card.

FOLD ON THIS LINE ONLY.

N. Ord. 41. *Serial No.* ....

POWDER CARD.

U. S. S. ....
(Place and date.)

APPROVED AND FORWARDED:

......................, *U. S. N., Commanding.*

(This space for Bureau's stamp.)

INSTRUCTIONS.

1. Forwarded to Bureau of Ordnance direct:

(*a*) Annually, July 1, showing quantities on hand, allowances, shortages, and headed, "Annual returns for ———."

(*b*) When changes occur, showing quantities on hand, allowances, and shortages for only those calibers in which changes occurred. In case of "Transferred to," make note on face of card showing reason and authority for transfer.

(*c*) When going into commission or reserve.

2. To be submitted by:

(*a*) All vessels in commission or in reserve that have ammunition on board or that have an ammunition allowance.

(*b*) Training stations and Marine Corps shore stations having ammunition or ammunition allowance.

(*c*) Naval vessels and organizations.

3. When ammunition is transferred from a ship to another ship, or to a station, this card, properly filled out, will accompany the transfer (copy being sent to Bureau direct). Make entry on face of card showing reason and authority for transfer, as, "For rebagging B. O. L. 2777 1/3 of 12-3-14."

4. In fixed ammunition the different "indexes" and "kinds" of powder will be on separate lines, and different "types of projectiles" assembled with the same index will be on separate lines.

5. Number reports serially, in upper right-hand corner. New series will begin with each calendar year, separate for target and service reports.

6. This card should be made out from an actual inventory and not from an old return.

7. "Index No." (column 1) will be entered except in case of small-arms ammunition and black powder. This is the only column on the card in which the "Index No." of the powder should be entered.

8. The "kind" of powder (column 2) will be designated: S. P., smokeless; S. P. R., smokeless rosanaline; S. P. D., smokeless diphenylamine; S. P. D. W., smokeless diphenylamine reworked; B. P., brown prismatic; Bk. P., black prismatic; Bk. F., black fine grain; Bk. C., black cannon (coarse grain about the size of peas); Sal., saluting powder (black). Saluting powder is considered part of the service allowance.

9. "How assembled" (column 3) will be designated: Sal., saluting charges; bulk, powder not made up in charges but carried in boxes or tanks; chgs., charges in bags or in cartridge cases without projectiles. For cartridges complete

[Original printed on white paper.]

N. Ord. 42a.

PROJECTILE CARD

Serial No. 4

TARGET-PRACTICE AMMUNITION *Annual return for July 1, 192*

U. S. S. ARKANSAS, 21 Oct. 1920
(Ship or station, and date.)

Expended for
Transferred N. A. D. Mare Island.
Received from
Cancel all except one showing reason for submitting card.

Lot Number and Year. 1.	Type and Mark. 2.	Weight and Nature of Bursting Charge. 3.	Fuse. Caliber. 4.	Fuse. Mark. 5.	Powder Index Number. 6.	Expended, Transferred, Received. 7.	On Hand at Date. 8.	Ship's Allowance. 9.	Short of Allowance. 10.	Gun. Caliber and Length. 11.	Gun. Mark. 12.
				Target Practice Ammunition.							
				S. R. B. P. 1920-21							
40&41-	T-XI-4	—	—	—	—	75	75	75	0	12/50	VII
1918											
				S. R. D. P. 1920-21							
40&41-	T-XI-4	—	—	—	—	36	36	36	0	12/50	VII
				Day Individual 1920-21							
29-1918	T-X-14	—	—	—	—	84	84	84	0	12/50	VII
				Division, 1920-21							
6-1914	T-X-7	—	—	—	—	32	32				
					Total		96	96	0	12/50	VII
34, 40,	T-X	—	—	—	—	80	80	80	0	5/51	VIII
17-1917											
				Day Torp. Defense 1920-21							
1, 3, 8, 9,	T-XX-8	—	—	—	—	160	160	160	0	5/51	VIII
				Experimental A. A.-1920-21							
—	Shrap-IX	08B1	—	XI-2	1112	40	40	40	0	3/50	X-2
				Gunnery Exercise and Ex-Caliber							
—	T	—	—	—	1500	2000	2000	1200	0	1-pdr	V
				Trial Board and Testing							
41-1918	T-XI-4	—	—	—	—	60	60	60	0	12/50	VII

I hereby certify that the tests, examinations, and inspections prescribed by the Department's orders and regulations have been fully complied with during the period since the last report.

John Doe, Comdr. *U. S. N., Gunnery Officer.*

READ CAREFULLY INSTRUCTIONS ON BACK OF CARD.

properly the projectiles. (See Ordnance Manual, Part IV.) Projectiles in service not marked in accordance with the latest instructions may be identified by markings on base.

8. "Type and mark" (column 2): Enter type and mark of projectiles. Use the following abbreviations for designating type: A. P., armor piercing; Com., common; F. N., flat nose; T., target; A. A., antiaircraft; S. S., illuminating projectile; shrap., shrapnel; Cl. B, Class B; L. V., for landing and field guns, low velocity.

9. "Weight and nature of bursting charge" (column 3) will be designated: D, explosive D; T., trinitrotoluol; Bl, black powder. The weights are given on the base of each projectile. (See Ordnance Pamphlet 368, Part II.)

10. "Fuse caliber" (column 4) will be designated maj., major caliber; med., medium caliber; and min., minor caliber. In the case of detonating fuses, enter det. in this column.

11. "Fuse mark" (column 5): Enter the mark of the fuse as stamped on it; such as, IV-a for Semple tracer fuse Mark IV-a; VII-1 for nose detonator fuse Mark VII, mod. 1, etc. In case the mark is not shown, enter in this column the letters which are stamped on the fuse.

12. "Powder, index No." (column 6) will be filled in for case ammunition only.

13. "Expended, transferred, received" (column 7) (cancel one (or two) not used.) If desired, both transfer and receipt may be reported on one card. If this is done, (1) cancel "expended," (2) write across face of card "transferred to ——," (3) make proper entries for transfer, (4) double space and write across face of card "received from ——," (5) make proper entries for receipts.

14. "On hand at date" (column 8) should show number of rounds *after* the change (in case of expenditure, transfer, or receipt). For example, if 250 12-inch projectiles are on board and 50 are received from a magazine, card reporting "Received from" should have 300 in column 9.

15. "Ship's allowance" (column 9) should agree with latest orders for gunnery exercises. If not on allowance list, enter "0" in this column.

16. "Short of allowance" (column 10) should show difference between amount on hand and amount allowed. From these entries orders are issued to ammunition depots for ammunition to keep vessels' allowances filled. Requisitions for ammunition are not necessary. (See Navy Regulations.)

17. "Gun, caliber and length" (column 11) will be designated: 12/50 for 12-inch 50-caliber gun; 5/51 for 5-inch 51 caliber gun; 3" F. G., for field gun 3" L. G., for landing gun; 6-pdr., for 6-pounder gun; etc.

18. Gun mark (column 12) will be designated: IX, for Mark 9; VII-2 for Mark 7, modification 2, etc.

19. Report all target-practice ammunition under heading (across face of card) "Target-practice ammunition—S. R. D. P.," etc., (or whatever form of practice it is for) 1919-20.

20. Small-arms ammunition, primers and superheater fuses (for torpedoes) should appear on powder card only, not necessary on projectile card.

21. Enter as "note" on face of card any necessary and important information not included in other portions of report.

FOLD ON THIS LINE ONLY

N. Ord. 42a.

Serial No. ....

PROJECTILE CARD

U. S. S. ....

....
(Place and date.)

APPROVED AND FORWARDED:

....

...................., *U. S. N., Commanding.*

(This space for Bureau's stamp.)

INSTRUCTIONS

1. Forward to Bureau of Ordnance direct (*a*) annually, dated July 1, showing quantities on hand, allowances, shortages, and headed "Annual returns." (*b*) When changes occur show amounts on hand, allowances, and shortages for only those calibers in which changes occurred. In case of "Transferred to," make note on face of card showing reason and authority for transfer.

2. To be submitted by (*a*) all vessels in commission that have target ammunition on board; (*b*) training stations, Marine Corps shore stations having target ammunition; (*c*) naval militia vessels or organizations having target ammunition.

3. When ammunition is transferred from a ship to another ship, or to a station, this card properly filled out will accompany the transfer (duplicate being sent to Bureau). Make entry on face of card showing reason and authority for transfer, as "Remnants of target-practice ammunition; C-in-C's letter ——."

4. In case ammunition the different types and marks of projectiles of the several calibers of guns will be entered on separate lines, and the different indexes of powder assembled with the same type or mark of projectile will be entered on separate lines.

5. Number report serially in upper right-hand corner. New series will begin with each calendar year. Separate serial numbers will be used for service ammunition.

6. This card should be made out from an actual inventory and not from an old return.

7. "Lot number and year" (column 1): Enter lot number and year as stamped on projectiles. Sufficient information must be given in this column and in column 2 to identify

[Original printed on salmon-colored paper.

N. Ord. 42—Rev.

PROJECTILE CARD

Serial No. 1

SERVICE AMMUNITION

Annual return for July 1, 192

Expended for

Transferred to

Received from

Cancel all except one showing reason for submitting card.

U. S. S. ARKANSAS, July 1, 192 1
(Ship or station, and date.)

Lot Number and Year.	Type and Mark.	Weight and Nature of Bursting Charge.	Fuse.		Powder Index Number.	Expended, Transferred, Received.	On Hand at Date.	Ship's Allowance.	Short of Allowance.	Gun.	
			Caliber.	Mark.						Caliber and Length.	Mark.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
2,3,4&6–	APVIII–5	23–D	Det	II	—	—	1154				
1910											
9–1911	APXIV–6	23–D	Det	II	—	—	156				
					Total		1310	1310	0	12″50	VII
2–1914	ComXIV–2						451				
1&11–1914	ComXV–2						582				
1–1912	ComXV–9				—	—	147				
1–1914	ComXV–11				—	—	20				
15,17,20,22,	ComXV–12				—	—	2457				
28&30–											
1913				Total	—	—	3840	3800	0	5″51	VIII
		B1									
8–1916	Shrap–IX	.18B1	—	XI–1	1207	—	200	200	0	3″50	X–2
5–1917	C1B–	.62T	—	XI–2							
	XVI–5		Det	VIII	1549	—	200	200	0	3″50	X–2
22–1917	SSXVIII–	.08B1	—	XI–2	736	—	100	200	100	3″50	X–2
	Mod. 1										
4–1914	Shrap	.05B1	—	XI	1091	—	300	300	0	3″LG	IV
	VIII										
73–1917	ComII–1	.03B1	Min	Semple	1462	—	1200	1200	0	1-pdr	V

I hereby certify that the tests, examinations, and inspections prescribed by the Department's orders and regulations have been fully complied with during the period since the last report.

John Doe, Comdr. *U. S. N., Gunnery Officer.*

READ CAREFULLY INSTRUCTIONS ON BACK OF CARD.

INSTRUCTIONS—Continued.

properly the projectiles. (See Ordnance Manual, Part IV.) Projectiles in service not marked in accordance with the latest instructions may be identified by markings on base.

8. "Type and mark" (column 2): Enter type and mark of projectiles. Use the following abbreviations for designating type: A. P., armor piercing; Com., common; F. N., flat nose; T., target; A. A., antiaircraft; S. S., illuminating projectile; shrap., shrapnel; Cl. B, Class B; L. V., for landing and field guns, low velocity.

9. "Weight and nature of bursting charge" (column 3) will be designated: D, explosive D; T., trinitrotoluol; Bl, black powder. The weights are given on the base of each projectile. (See Ordnance Pamphlet 368, Part II.)

10. "Fuse caliber" (column 4) will be designated: Maj., major caliber; med., medium caliber; and min., minor caliber. In the case of detonating fuses, enter det. in this column.

11. "Fuse mark" (column 5): Enter the mark of the fuse as stamped on it; such as IV-a for Semple tracer fuse Mark IV-a; VII-1 for nose detonator fuse Mark VII, mod. 1, etc. In case the mark is not shown, enter in this column the letters which are stamped on the fuse.

12. "Powder, index No." (column 6) will be filled in for case ammunition only.

13. "Expended, transferred, received" (column 7) (cancel one (or two) not used). If desired, both transfer and receipt may be reported on one card. If this is done, (1) cancel "expended," (2) write across face of card "transferred to ——," (3) make proper entries for transfer, (4) double space and write across face of card "received from ——," (5) make proper entries for receipts.

14. "On hand at date" (column 8) should show number of rounds *after* the change (in case of expenditure, transfer, or receipt). For example, if 250 12-inch projectiles are on board and 50 are received from a magazine, card reporting "Received from" should have 300 in column 9.

15. "Ship's allowance" (column 9) should agree with latest revisions to allowance lists. If not on allowance list, enter "0" in this column.

16. "Short of allowance" (column 10) should show difference between amount on hand and amount allowed. From these entries orders are issued to ammunition depots for ammunition to keep vessels' allowances filled. Requisitions for ammunition are not necessary. (See Navy Regulations.)

17. "Gun, caliber and length" (column 11) will be designated: 12/50 for 12-inch 50-caliber gun; 5/51 for 5-inch 51-caliber gun; 3" F. G., for field gun; 3" L. G., for landing gun; 6-pdr., for 6-pounder gun; etc.

18. Gun mark (column 12) will be designated: IX, for Mark 9; VII-2 for Mark 7, modification 2, etc.

19. Ammunition on hand or received for any other purpose than to fill service allowance should be so indicated under a self-explanatory heading written across the face of the card. Always report target-practice ammunition on Form 42a.

20. Small-arms ammunition, primers and superheater fuses (for torpedoes) should appear on powder card only, not necessary on projectile card.

21. Enter as "note" on face of card any necessary and important information not included in other portions of report.

FOLD ON THIS LINE ONLY

N. Ord. 42—Rev. *Serial No*.................

PROJECTILE CARD

U. S. S. ....

....

(Place and date.)

APPROVED AND FORWARDED:

....

.........................., *U. S. N., Commanding*

(This space for Bureau's stamp.)

INSTRUCTIONS

1. Forward to Bureau of Ordnance direct (*a*) annually, dated July 1, showing quantities on hand, allowances, shortages, and headed "Annual returns." (*b*) When changes occur, show amounts on hand, allowances, and shortages for only those calibers in which changes occurred. In case of "Transferred to," make note on face of card showing reason and authority for transfer. (*c*) When going into commission or reserve.

2. To be submitted by (*a*) all vessels in commission or in reserve that have ammunition on board or that have an ammunition allowance; (*b*) training stations, Marine Corps shore stations having ammunition or ammunition allowance; (*c*) naval militia vessels or organizations.

3. When ammunition is transferred from a ship to another ship, or to a station, this card properly filled out will accompany the transfer (duplicate being sent to Bureau). Make entry on face of card showing reason and authority for tranfer.

4. In case ammunition the different types and marks of projectiles of the several calibers of guns will be entered on separate lines, and the different indexes of powder assembled with the same type or mark of projectile will be entered on separate lines.

5. Number report serially in upper right-hand corner. New series will begin with each calendar year. Separate for service and target practice.

6. This card should be made out from an actual inventory and not from an old return.

7. "Lot number and year" (column 1): Enter lot number and year as stamped on projectiles. Sufficient information must be given in this column and in column 2 to identify

[Original printed on white paper.]

N. Ord. 70 (b)

SHIP U. S. S. ARKANSAS. DATE July 1, 1921.

TARGET PRACTICE AMMUNITION EXPENDED DURING FISCAL YEAR.

GUN.		POWDER.		PRIMERS.		PROJECTILES, LOADED.		9	10
1	2	3	4	5	6	7	8	TOTAL COST.	OBJECT OF EXPENDITURE.
Caliber and Length in Calibers.	Mark.	Number Rounds Expended.	Cost of All Powder Fired.	Number Expended.	Cost.	Number Expended.	Cost of All Projectiles.		
	Full Charges								
5/51	VIII	240	4169.00	243	81.00	240	2,050.62	6,300.62	DIV&DTD
		# NOTE: Illuminating projectiles from service allowance.							
1-pdr	V	1066	—	1066	—	1066	—	660.92	EX-
	Reduced Charges								CAL
12/50	VII	207	24,771.56	207	69.00	207	11,200.00	36,040.56	SRB
									SRD&
				Drill Primers					NTD
						TOTAL		$44,466.04	

MISCELLANEOUS AMMUNITION EXPENDED.

KIND OF AMMUNITION.	MODEL.	CAL.	NUMBER OF ROUNDS EXPENDED. Ball.	Cost.	Blank.	Cost.	TOTAL COST.
Rifle	1906	.30	45,700	2,030.00	300	12.46	2,042.46
Rifle	1898	.30	200	3.00	9000	23.45	26.45
Rifle	Old models	.45					
Rifle	Target	.22					
Machine Gun	1906	.30					
Machine Gun	1906 Incendiary	.30					
Machine Gun	1906 Tracer	.30					
Machine Gun	1906 Armor Piercing	.30	14,400	425.46			425.46
Pistol	Colt Automatic	.45					
Revolver	Double action	.38					
Stokes Mortar	Complete rounds	3″					
Hand Grenades							
				TOTAL			$2,494.37

Grand Total $51,095.43

Approved:

J. B. Crane, Capt., *U. S. N.*,
Commanding.

John Doe, Comdr., *U. S. N.*,
Ordnance Officer.

N. Ord. 70 (b)

TARGET PRACTICE AMMUNITION EXPENDITURE CARD.

1. To be forwarded to the Bureau of Ordnance direct, annually, dated July 1, or on date of going out of commission, showing the cost of all target practice ammunition expended during the fiscal year by ships or stations holding target practice.

2. Expenditure of service ammunition will be reported separately on Form N. Ord. 70 (a).

3. Data for columns 4, 6, 8, and 9 will be obtained from invoices received from the ammunition depots. In case no invoices are received, ships and stations will take steps to obtain them direct.

4. Issues of ammunition to ships and stations will not be reported on this form by ammunition depots. However, expenditures for station use will be reported by all stations.

5. Invoices covering ammunition will show the cost of powder per round, the cost of the primer, the cost of the loaded projectile, and the total cost per round.

6. In column 5 enter the primers used for the ammunition expended. At the bottom, opposite "Drill," enter the cost of drill primers used throughout the fiscal year.

7. In column 10 enter the object for which the expenditure was made, i. e., "S. R. B. P.," "Gun test," "Exp.," etc.

8. Ammunition transferred will not be included in this report.

9. Cost of cartridge cases, tanks, or boxes will not be included in this report.

10. Report full and reduced charges separately.

11. Attention is invited to the Naval Instructions regarding not throwing ammunition overboard.

12. Illuminating projectile ammunition from service allowance fired at target practice will be reported as target practice ammunition.

N. Ord. 70 (a) Rev. Original printed on salmon-colored paper.)

SHIP U. S. S. ARKANSAS DATE JULY 1, 1921

SERVICE AMMUNITION EXPENDED DURING FISCAL YEAR.

GUN.		POWDER.		PRIMERS.		PROJECTILES, LOADED.		9	10
1 Caliber and Length in Calibers.	2 Mark.	3 Number Rounds Expended.	4 Cost of All Powder Fired.	5 Number Expended.	6 Cost.	7 Number Expended.	8 Cost of All Projectiles.	Total Cost.	Object of Expenditure.
12/50	VII	84	$16,756.48	84	29.58	48	$684.52	$17,470.58	DISP
3/50	X	40	—	40	—	40	—	601.86	EXP
									AA
5/51	VIII	20	322.18	22	7.80	20	752.26	1,082.30	#
					# At de	relict o	rders C in	C.	
				Other Service Primers	3.58			3.58	
							TOTAL	$19,158.32	

MISCELLANEOUS AMMUNITION EXPENDED.

Kind of Ammunition.	Model.	Cal.	Number of Rounds Expended.				Total Cost.
			Ball.	Cost.	Blank.	Cost.	
Rifle	1906	.30					
Rifle	1898	.30					
Rifle	Old models	.45					
Rifle	Target	.22					
Machine Gun	1906	.30					
Machine Gun	1906 Incendiary	.30					
Machine Gun	1906 Tracer	.30			NONE		
Machine Gun	1906 Armor Piercing	.30					
Pistol	Colt Automatic	.45					
Revolver	Double action	.38					
Stokes Motar	Complete rounds	3″					
Hand Grenades							
						TOTAL	0

Grand Total $19,158.32

Approved:

J. B. Crane, Capt., U. S. N.,
Commanding.

John Doe, Comdr., U. S. N.,
Ordnance Officer.

N. Ord. 70 (a) Rev.

SERVICE AMMUNITION EXPENDITURE CARD.

1. To be forwarded to the Bureau of Ordnance direct, annually, dated July 1, or at date of going out of commission, showing the cost of all service ammunition expended by firing during the fiscal year, only in case expenditures have been made. Expenditure of target practice ammunition will be reported separately on Form N. Ord. 70 (b).

2. Data for columns 4, 6, 8, and 9 will be obtained from invoices received from the ammunition depots. In case no invoices are received, ships and stations will take steps to obtain them direct.

3. Issues of ammunition to ships and stations will not be reported on this form by ammunition depots. However, expenditures for station use will be reported by all other stations.

4. Invoices covering ammunition will show the cost of powder per round, the cost of the primer, the cost of the loaded projectile, and the total cost per round.

5. In column 5 enter the primers used for the ammunition expended. At the bottom, opposite "Service Primers," enter the cost of service primers used throughout the fiscal year. Drill primers will be shown on Form N. Ord. 70 (b).

6. In column 10 enter the object for which the expenditure was made, i. e., "D. I. S. P." "Exp.," "Service," etc.

7. Ammunition transferred will not be included in this report.

8. Cost of cartridge cases, tanks, or boxes, will not be included in this report.

9. Report full and reduced charges separately.

10. Attention is invited to the Naval Instructions regarding not throwing ammunition overboard.

11. Illuminating projectile ammunition from service allowance fired at target practice will be reported on Form N. Ord, 70 (b).

Chapter XXIV.

SPECIAL TESTS ON AMMUNITION.

1. Ordnance Pamphlet No. Ord. 4 contains instructions and information for the service at large regarding ammunition and tests of powders. Special instructions not contained therein, as they apply more particularly to ammunition depots, are accordingly included in Ordnance Manual, Part V. (To be reissued as Ordnance Pamphlet No. Ord. 5.) **Special tests for ammunition depots.**

2. Military guncotton is cellulose nitrate of high nitration. It was formerly used wet as the explosive charge for mines and torpedoes, and in the dry state as boosters, formerly called dry guncotton primers. Dry guncotton boosters may be stored in the wet state for purposes of safety and stability. There are still available a number of mine and torpedo guncotton charges, and a few boosters are still on hand which are gradually being scrapped as they become unserviceable and are not being replaced, as T. N. T. has become the prime explosive charge material. T. N. T. boosters are replacing guncotton boosters even in war heads loaded with wet guncotton. Guncotton was formerly issued to the service with different percentages of moisture, ranging from 20 to 35 per cent. At present all guncotton retained for service, regardless of the use to which it is to be put, should contain 25 per cent of moisture, i. e., to dry guncotton is added 25 per cent of its weight in pure distilled water. In case this change has not been effected, the percentage of moisture will not be changed, but the markings on the container will govern the amount the guncotton should contain, this weight being the weight of the charge *wet*. No further loading of war heads or mines with guncotton is anticipated. **Guncotton.**

3. Pending the entire replacement of guncotton the instructions contained herein shall be followed. The explosive charge is detonated by means of the booster which is detonated by a charge of fulminate of mercury in the "detonator."

4. Dry guncotton boosters for torpedoes are cylindrical in shape, made up in blocks, each with an axial hole to take the detonator. The size of these blocks is 2 inches in height, $1\frac{11}{16}$ inches outside diameter, with a $\frac{9}{16}$-inch central perforation. When dry they are kept in glass jars with tight covers to exclude moisture. One booster is stowed in each jar and the jars stowed two, four, or six in a wooden box. Strips of blue litmus paper are placed between the blocks, and for convenience in handling the blocks are tied together with pieces of tape. The dry guncotton boosters for mines were made up in rectangular blocks 2.9 by 2 inches with a $\frac{9}{16}$-inch central perforation. They are stowed in glass jars similar to torpedo boosters. **Dry guncotton boosters.**

5. Wet guncotton boosters are of the same size as the dry. The latest practice is to pack all boosters for one outfit in one package in water, hermetically **Wet guncotton boosters.**

sealed, with a filling hole for making up losses in water. They are shipped in the wet state for safety reasons, governed by restrictions imposed by the Interstate Commerce Commission. They may be removed from their containers on receipt and dried and thereafter stowed and handled as dry boosters. They may be dried by exposure in a steam dryer or by exposure to a dry atmosphere.

Drying by exposure in steam drier.

6. (*a*) The steam dryer must be located above the water line, remote from fires and lamps and in such a position that it will not be subject to disarrangement. Its supply of steam is to be derived from a suitable part of the steam-heating apparatus of the ships or from any convenient source of low-pressure steam by piping at a navy yard.

(*b*) The blocks are to be dried, weighed separately, and the weight of each is to be marked on the block with a soft lead pencil (never putting labels of any kind on the guncotton). The blocks are then to be strung on rods, with iron washers between them, and placed in wire baskets. The baskets are placed in the drier, the door closed, the thermometer put in place, steam turned on, and the ventilating openings are adjusted. The baskets, rods, and washers must be kept free from dirt and oil. The temperature of the drying chamber must not exceed 100° F.

(*c*) After each day's heating the blocks are to be removed carefully and weighed; the weights are to be marked on the blocks, and the drying is then continued. This process is to be repeated until the blocks no longer lose weight, when all but a small percentage of moisture will have been expelled.

(*d*) When the drying is completed the blocks are to be removed from the drier and placed, while still warm, in the glass jars with strips of blue litmus paper between them. The jars are to be closed tightly and the guncotton is then to be stowed and inspected as dry guncotton.

Drying by exposure in dry atmosphere.

7. String the blocks to be dried on a wood, brass, or copper rod or pipe, which must be free from dirt and oil, or place them on a shelf made of wire netting, separating the blocks from each other to expose all surfaces freely to the air; suspend the rod or shelf in some suitable place, not in vicinity of the galley or other fires, where the blocks will be freely exposed to the air and be under cover.

(*a*) Expose the blocks only when the atmosphere is dry; at all other times keep them in an empty powder tank, in the immediate vicinity of the place selected for drying, kept closed to exclude moisture. Weigh the blocks every two days, noting on the blocks the date and weight with a soft lead pencil. Continue the drying until the blocks show no loss of weight for two consecutive weighings, the weather being moderately dry. Then place the blocks in the glass jars, with strips of blue litmus paper between, and treat them according to the rules given for dry guncotton primers. Avoid unnecessary handling of the blocks, as they are apt to flake and crumble.

Stowage of wet guncotton.

8. Torpedo war heads and mines containing wet guncotton charges are stowed in war-head or mine-charge magazines. Magazines aboard ship are fitted for ventilating, flooding, etc., similarly to magazine compartments containing other explosives. Wet guncotton may be stowed in the war-head or mine-charge magazines with the main charges.

Stowage of dry guncotton.

(*a*) Dry guncotton when issued is in glass jars which are packed in wooden boxes. These wooden boxes are stowed aboard ship above the water line in cool, dry, secure places, as far as possible from fires or shock from gunfire. Unless otherwise specified, the normal stowage location for dry guncotton boxes will be in the ward room and cabin spaces. The boxes should be stowed at least 10 feet from each other and should not be stowed near wet guncotton charges or detonators, or electric fixtures, such as switchboards, junction boxes, or conduits. Ashore, dry guncotton is stored in separate, detached magazines, but it is preferable to keep it wet and store it with wet guncotton main charges.

High temperature to be avoided.

(*b*) Magazines in which guncotton is stored should not be allowed to attain a temperature as high as 100° F. for any great length of time. The diurnal changes of temperature will not affect guncotton, wet or dry, provided the cases or boxes containing it are not exposed to the sun.

Not to be exposed to direct rays of the sun.

(*c*) Guncotton must not at any time be exposed to the direct rays of the sun. Avoid, also, as much as possible exposing any box or case containing guncotton, either wet or dry, to the direct rays of the sun for any length of time, as the temperature inside the container can in this way be raised to a point considerably above that of the open air, and this temperature will be maintained for a considerable time after the exposure. Moreover, in removing from their cases the glass jars holding the dry guncotton never expose them to the direct rays of the sun, as the glass may act as a lens and cause ignition.

Precautions against contamination.

(*d*) Care should be taken not to handle guncotton more than is absolutely necessary with bare hands and to avoid touching guncotton with oil or acid of any kind. The directions given in Part IV of the Ordnance Manual, to wash any container for guncotton in strong soda solution before loading, should always be followed in order to remove thoroughly acids or any other impurities which would tend to cause deterioration in the guncotton.

Special precautions with dry guncotton.

(*e*) Dry guncotton must be handled with care and protected from shock. It is highly inflammable, and in case of fire near its place of stowage should be removed to a place of safety, or, in emergency, when afloat, thrown overboard. If ignited, dry guncotton boosters will burn so quickly and violently as to cause considerable explosive effect, even if not reaching detonation.. Its effect will be to produce a considerable area of gas sufficient to burn anyone in the vicinity and project parts of containers with great force, but not sufficient to cause sympathetic detonation at 10-foot intervals.

Inspection of guncotton required.

9. The following inspections of guncotton must be regularly made, and the results entered in the log.

Weekly: All dry guncotton.
Monthly: All dry guncotton.
Quarterly: All wet guncotton.
Annually: All guncotton (at naval ammunition depots).

Weekly inspection.

10. All dry guncotton boosters must be inspected weekly. This is to be done without opening the glass jars, by observing the condition of the blocks and the strips of blue litmus paper between them.

(*a*) In the event of any serious decomposition having taken place, the guncotton will be found more or less covered with pasty yellow spots, or the jar may be filled with brownish red, highly acid fumes, and the litmus paper will show a decided red color.

Procedure with decomposing guncotton.

(*b*) If the guncotton is actually decomposing, it should be destroyed after a sample block has been set aside for reference. This sample should be placed in a clean glass bottle, wet thoroughly with pure water, and the bottle closed tightly. At the first opportunity it should be forwarded with a full statement of the facts, direct to the naval proving ground, in order that its condition may be examined carefully and the diagnosis verified, a copy of the statement of facts being forwarded at the same time to the Bureau of Ordnance. No guncotton is to be destroyed unless it is very clearly in the condition above described.

(*c*) Do not mistake iron rust for pasty yellow spots. Guncotton sometimes becomes rusted in the course of manufacture or from the case in which it is packed. The rust, except when present in considerable quantity, does no harm. Whenever any guncotton becomes badly discolored from iron rust it should be returned to the torpedo station.

(*d*) It frequently occurs that the blue litmus paper becomes faded by exposure in the jars, but no danger is to be apprehended in consequence.

(*e*) If the litmus paper has become reddened, but no fumes or pasty spots are observed, the guncotton should be given the litmus test described below.

Litmus test of guncotton.

11. The dry guncotton blocks are lifted out of the glass jar by the loose ends of the tape and placed on a perfectly clean, dry piece of blotting paper, being careful not to touch them with the fingers. (A perfectly clean dry crash towel may be used in handling the blocks.) Remove the strips of litmus paper, insert freshly moistened strips in their places, and tie the tape as before. After an hour's interval examine the ends of the strips of litmus paper. If they have become reddened, replace the blocks of guncotton in the jar, wet them thoroughly with pure water, and at the first opportunity forward the jar and its contents to the torpedo station. In this latter case none of the guncotton is to be destroyed, as there is a much greater chance for error in inspection.

(*a*) If the moistened strips of litmus paper have not become reddened after one hour's exposure, replace the blocks in the jar, close it tightly and replace it in its box.

Precautions in making litmus test.

(*b*) Only standard blue litmus paper furnished by the naval proving ground should be used in conducting tests of guncotton. Litmus paper should never be touched with the bare hand but should always be handled with forceps. The litmus paper should always be moistened before making the test, using pure distilled water. In moistening the paper, hold the strip in the forceps, dip a glass rod in distilled water, and then apply the moist rod to the paper; the paper should be moist only and not flooded with water.

(*c*) To check the absence of an acid reaction, make a comparative test by taking two pieces of fresh blue litmus paper and moisten one with distilled water and the other with dilute vinegar. The vinegar will give a bright red color, which shows what the actual color should be when made by acid or acid fumes. This test is very desirable in case of doubt, as blue litmus paper may sometimes appear slightly red when moistened with distilled water only.

(*d*) Always examine the test papers by white light. Litmus paper will present a reddish appearance in any compartment that is shellacked or colored; the examination of test papers should therefore be made only in a well-lighted room or open air.

(*e*) Do not touch the guncotton blocks with the bare hands and avoid unnecessary handling of the blocks, as they may flake or crumble.

Monthly inspection.

12. Even if no change is observed in the litmus paper at the weekly inspection, the litmus test just described, with fresh strips of moistened blue litmus paper, is to be applied to all dry guncotton once each month; this constitutes the monthly and quarterly inspections. In case the guncotton is decomposing, the procedure described under "weekly inspection" is to be adopted.

Quarterly inspection.

13. The wet guncotton is packed in the torpedo war heads or mine-charge cases and the weight of the wet guncotton and its containing case is stamped on the case. The guncotton contains as nearly as possible 25 per cent of water. These cases are again packed in stowage boxes, and the gross weight of wet guncotton, war head, or mine-charge case, and stowage box are stamped on the outside of the box. The stowage boxes are to be weighed every three months, and any loss in the gross weight is to be made up by the addition of pure water poured through the filling hole in the war head, mine case, etc., which is then to be closed carefully.

Annual inspection.

14. At ammunition depots samples shall be taken from packages of guncotton (war heads, mine, and wrecking charges) that have been loaded one year or that have been turned in by ships, and submitted to a heat test, this test to be repeated annually. The method of conducting this test is described hereinafter. Samples for this test should be taken from the interior of the blocks, as the surface of the blocks are likely to become slightly contaminated in service.

High stability of wet guncotton.

(*a*) The passing heat test for new guncotton under the latest specifications is 35 minutes, but originally this test was only 15 minutes, and much of the guncotton procured at that test (e. g., United States Navy, 1886, and Du Pont, 1892 and 1893) is still in service as wet guncotton. The stability of guncotton when wet is very high and all wet guncotton may be considered safe and satisfactory for issue to the service which gives a heat test of over two minutes. Wet guncotton giving a heat test of less than two minutes shall be made the subject of a special report to the Bureau of Ordnance in order that instructions may be issued regarding its disposition.

Passing heat test for dry guncotton.

(*b*) The heat test for dry guncotton should not be less than 20 minutes, and no wet guncotton shall be dried for use as dry boosters which gives a heat test of less than 20 minutes except in case of emergency when guncotton of better stability is not available. It is preferable that dry guncotton boosters should be of such stability as to give the standard heat test of 35 minutes.

Only guncotton of good stability issued.

(*c*) In case guncotton is issued to vessels it will be tested immediately before it is shipped, and none whose test is low will be issued. As a further precaution a small quantity from every lot of guncotton received at Rose Island is reserved for test, and these tests are continued as long as any of the lot remains in service. For these tests all dry guncotton is submitted to a heat test monthly and all wet guncotton to a heat test quarterly. In addition, a complete history of every lot of guncotton received at and expended from the magazine on Rose Island is kept on file for reference.

Instructions for conducting heat tests of smokeless powder and guncotton.

Heat test; where made.

15. The heat test of smokeless powder and service guncotton will hereafter be made only at naval ammunition depots and shore stations regularly equipped for conducting them. The surveillance test is decidedly more accurate and regular, and when possible will be the standard method for determining the stability of smokeless powder. The heat test will be relied on only when an immediate result is desired regarding the condition of a sample of smokeless powder or when it is impracticable to conduct a surveillance test, but in such cases the surveillance tests will be proceeded with in the usual manner at the earliest practicable moment.

When made.

16. The heat test, if properly conducted, is of value in the case of doubtful powders, as it requires much less time than a surveillance test, and nothing in the previous paragraph shall prevent the officer in charge of powder tests from supplementing the surveillance tests in this manner or from conducting heat tests frequently on powders of doubtful condition or recently received with a doubtful or unsatisfactory history. Stabilized indexes need not be given the heat test.

17. Heat tests are to be conducted in accordance with the instructions given below and are to be reported on Bureau of Ordnance Forms 67, revised, and 67A for all powders held available for issue.

Acceptable limit.

18. A serviceable powder should give a heat test of at least 10 minutes, and if less than 10 minutes is obtained, a special report will be made to the Bureau of Ordnance.

Heat test outfit.

19. The heat test outfit is issued to all naval ammunition depots and consists of a box containing apparatus and reagents for making heat tests of smokeless powder and guncotton; also litmus tests of guncotton. The list of contents of the outfit is as follows:

1 oil stove.
1 copper bath.
1 cover for bath.
1 thermometer.
1 rubber stopper.
6 watch glasses.
2 dozen test tubes.
1 pair of forceps.
1 dozen holders.
4 glass rods.
1 bottle glycerin solution.
2 bottles of K. I. starch paper.
2 bottles litmus paper.
1 bottle distilled water.
1 blue print.

(*a*) The water bath (Pl. I), consisting of a flat-bottomed cylindrical copper vessel about 10 inches in diameter and 5 inches deep, is filled to within a quarter-inch of its edge with water, or a mixture of glycerin and water, such as recoil-cylinder mixture. It has a loose-fitting cover of sheet copper, to the underside of which perforated tubes of thin sheet copper are soldered. These are from 2¼ to 2½ inches long and serve to keep the test tubes at the proper depth during the test.

(*b*) A kerosene stove about 10 inches high, having two burners which are fitted for wicks 3 inches wide, is used to heat the liquid in the bath. This stove is provided with a round top 8 inches in diameter upon which the bath rests. The top of the oil chamber is made dish shape. This should be filled with water while the stove is in use, as it keeps the surface of the oil cool and prevents an explosion. In case there is no kerosene oil available, ordinary alcohol may be used as a source of heat.

(*c*) The test tubes are made of glass of uniform thickness and are standard 5½ inches long, ½ inch internal diameter, and ⅝ inch external diameter, closed by a clean cork stopper fitting tightly, through which passes a tight glass rod holder.

(*d*) The holder is made of thin glass tubing or rod, 4 to 5 inches long, into the lower end of which is fused a platinum wire 1 inch long. This wire is bent into the form of a hook ½ inch long and serves for suspending the test paper in the heat-test tube. The rod is fitted into the test tube by means of the perforated cork stopper. Corks are discarded after one test.

(*e*) A chemical thermometer, graduated up to 110° to 120° C., is fitted into a hole in the center of the cover of the water bath by means of a perforated rubber stopper.

(*f*) A pair of brass forceps, bone-tipped, is furnished for handling the test paper.

(*g*) The heat-testing paper is known as "K. I Starch paper" and is prepared by immersing a special grade of filter paper in a specially prepared solution of cornstarch and potassium iodine (recrystallized from alcohol) and drying in a dark room. The proving ground is the designated source of supply for this paper and only the standard paper supplied from the proving ground will be used for conducting heat tests. This paper must be kept in the black glass bottles in which supplied, tightly sealed, and stowed in a dark place. It is furnished in strips about 1 inch long and ⅜ inch wide.

(*h*) The glycerin solution is made by diluting chemically pure glycerin with an equal volume of distilled water. Pure medicinal glycerin will serve for this purpose. It is issued in a small bottle, the mouth of which is closed by a cork, and the latter is perforated to take a small rod which reaches to the bottom.

Operation of the heat test for smokeless powder.

20. Sample powder grains are selected from the powder to be tested, and these grains are thoroughly cleaned by scraping. A sufficient amount is then scraped off with glass or a scraper, the scrapings not to be more than 0.002 inch thick. In the case of small caliber powders, such as those for 1-pounder guns and small arms, the sample should be tested in its original condition. The sample is dried on watch glasses at a temperature as near 43° C. as possible, for 48 hours and then allowed to stand for a sufficient time to take on the proper amount of moisture, which is between 1.5 and 2 per cent. Exposure over night at about 70° F. will give good results.

(*a*) Twenty grains (1.3 grams) of the powder, prepared for the test in the manner described, are weighed into the test tube and pressed down to occupy about 1½ to 1¾ inches of tube. The sides of the test tube are freed from any adhering particles of the powder dust by wiping with a roll of clean tissue paper. An incision is made in the test paper near one end with the point of a penknife. The paper is hung on the platinum wire of the holder with the aid of the forceps. Do not touch the paper with the bare hand. To moisten the paper, grasp the holder in one hand with the paper uppermost. Touch the edge of the paper near the wire with the drop of glycerin solution on the glass rod in the bottle. This will wet the paper for about one-half its length. The test paper, fastened to the platinum hook and moistened with the glycerin solution, is then inserted in the test tube and is drawn up by its holder close to the cork.

(*b*) The stem of the thermometer is immersed in the bath to the same depth as the test-tube holders on the underside of the bath cover. When the temperature of the bath is constant at 65.5° C., the tubes are placed in the holes of the bath cover. The time of insertion is noted by a watch. After the heating has continued for a brief time, a slight film of moisture forms in a ring in the upper part of the test tube. The proper amount of moisture gives a frosty appearance on the tube. If drops form on the inside of the tube, there is too much moisture in the powder. When the ring of moisture forms, the test paper is lowered by pushing the holder through the cork until the line of demarcation between the wet (upper) and the dry (lower) portions of the test paper is coincident with the lower edge of the ring of moisture. If there is any subsequent change in the position of the ring of moisture, the test paper is moved accordingly. Plate I shows the general arrangement of apparatus for the test.

(*c*) The test paper is now observed carefully, and when the least brownish or yellow discoloration appears at the line of demarcation between the wet and the dry portions of the test paper, the time is again noted and the elapsed time since inserting the tube in the bath is recorded as the period of the test. The discoloration should be greater than that obtained at the same time by a blank test. If no discoloration appears at the end of 40 minutes, the heat test is discontinued, and the results of the test are recorded as 40 minutes plus.

(*d*) It is obviously necessary that the apparatus should be placed in such a position that a strong white light is transmitted through the test paper. The kerosene stove is easily regulated so as to maintain a temperature throughout the test within 1° of 65.5° C., and this variation in the temperature is allowed.

Heat test for guncotton. **21.** Guncotton in store at naval ammunition depots is given a heat test annually, this applying to guncotton in bulk and in war heads, mine and wrecking charges, and wet and dry boosters.

(*a*) To prepare a sample of guncotton for the heat test, split one of the blocks and scrape a sample from the interior with a knife. Carefully avoid contamination of the sample by contact with the hands or otherwise. The block being used for the preparation of the heat test sample should be in a moist condition to prevent ignition when scraping and, if a block of dry guncotton, should be first moistened with distilled water.

(*b*) The scrapings are rubbed in a clean cloth to mix and break up the small lumps. They are then spread out on clean paper trays or watch glasses and dried by exposure to air or in a heater at about 40° C. just a sufficient length of time to reduce the moisture to about 1.5 per cent. The whole item of drying should not exceed eight hours.

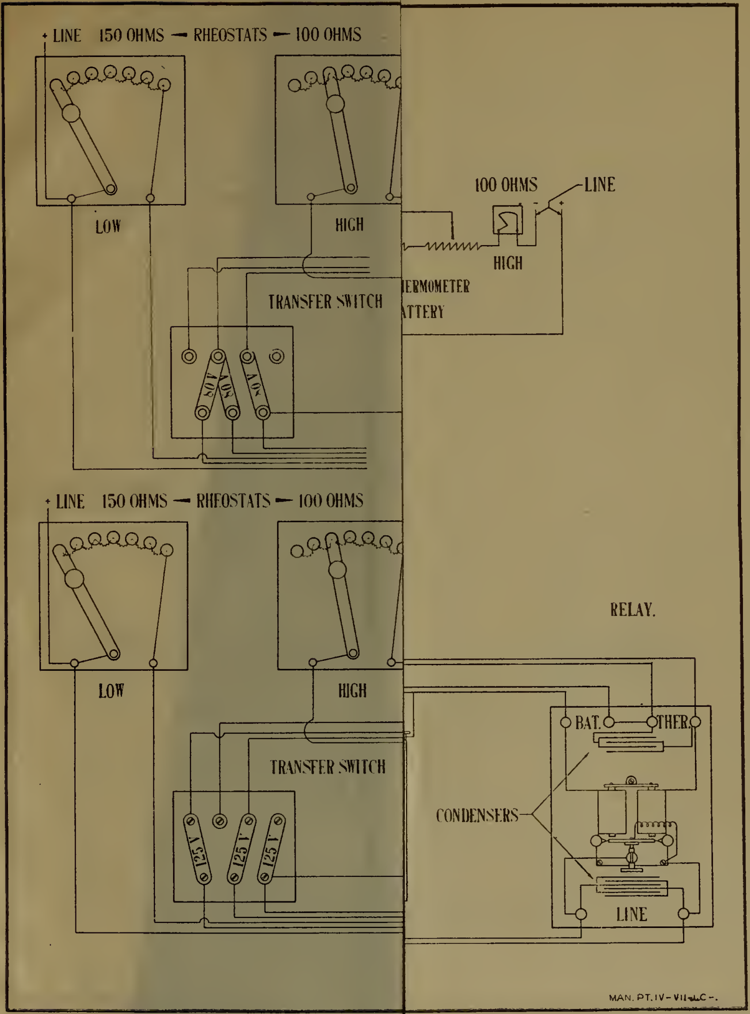
(*c*) The dried sample for the heat test is weighed out in five test tubes, 1.3 grams (20 grains) to each tube, so that a series is obtained covering the widest variation allowed for moisture. The guncotton is pressed or shaken down in the tube until it occupies a space of about 1⅝ inches. Thereafter the test is conducted exactly as prescribed for conducting heat tests of smokeless powder in paragraph 19 above. The lowest test given by the five tubes is considered the heat test of the guncotton in question.

22. The heat test is a very delicate one for free nitrous acid, and the presence of the slightest trace of acid from any extraneous source will render the test useless and misleading. The greatest care must be taken that there is no trace of acid on any of the articles used or on the hands of the person making the test. It is essential that the test should be conducted in a room which is free from acid fumes. **Delicacy of heat test.**

23. The litmus test of guncotton is given in connection with the weekly and monthly inspections, and these inspections are required of guncotton in store at naval ammunition depots as well as aboard ship. **Litmus test of guncotton.**

CHAS. B. MCVAY, JR.,
Chief of Bureau.

NAVY DEPARTMENT,
BUREAU OF ORDNANCE,
September, 1923.


+ LINE
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LOW
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TRANSFER SWITCH
40 V
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TTERY
+ LINE
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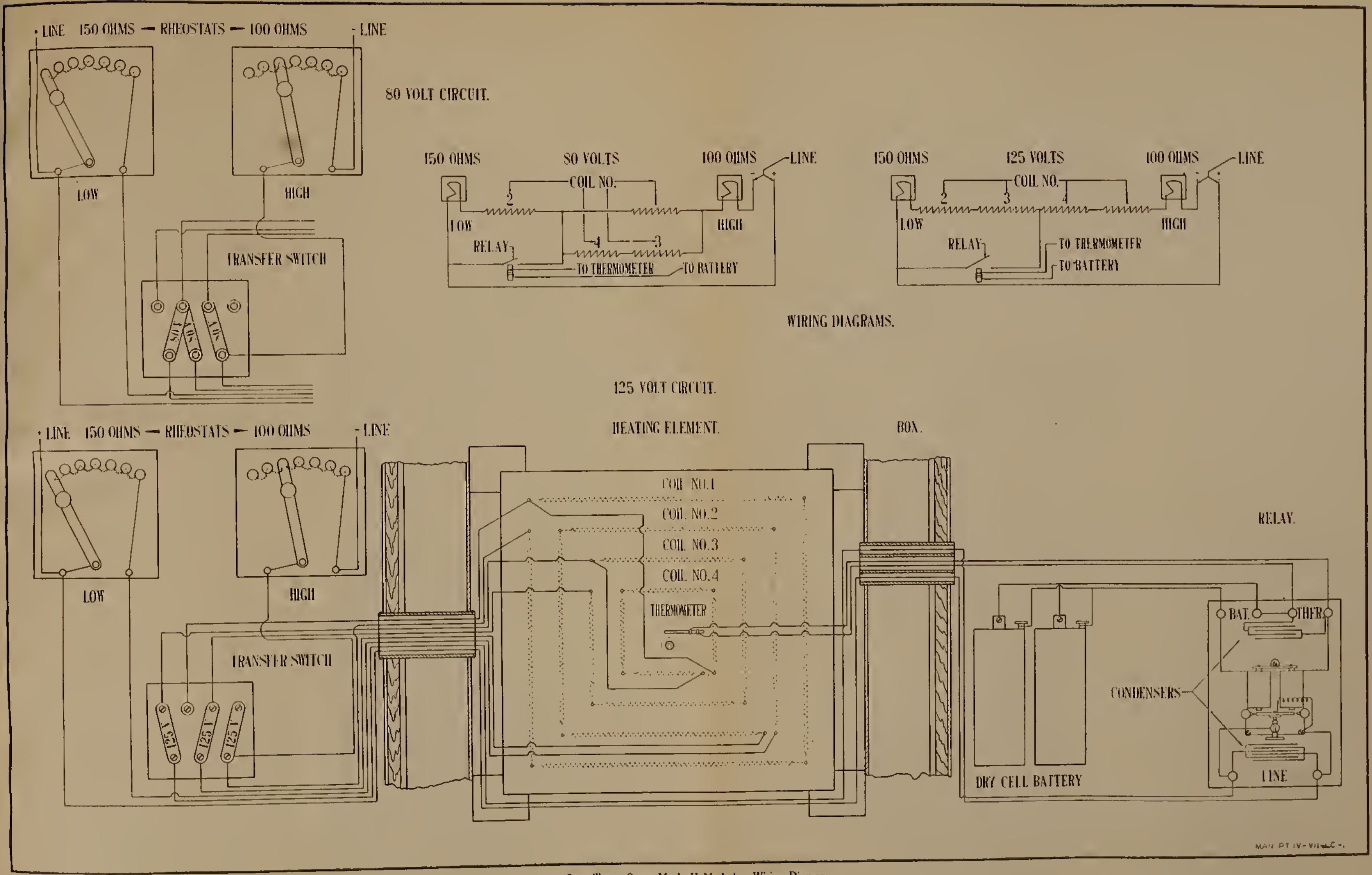
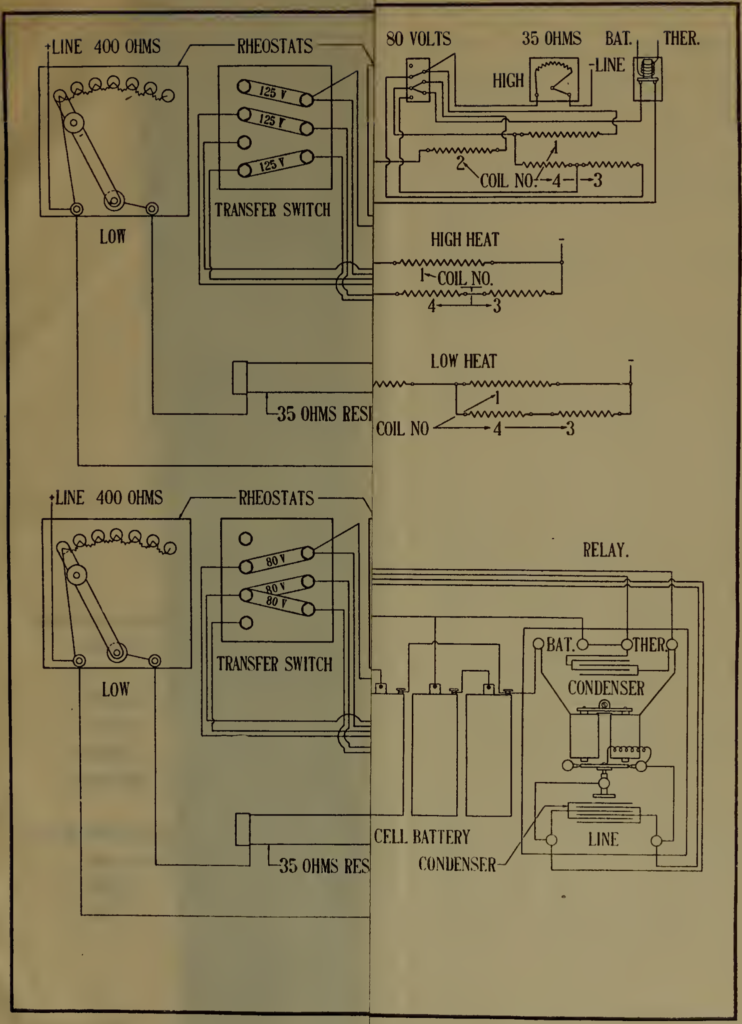


Surveillance Oven, Mark II Mod. 1. Wiring Diagram.

PLATE LV.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2
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HIGH HEAT
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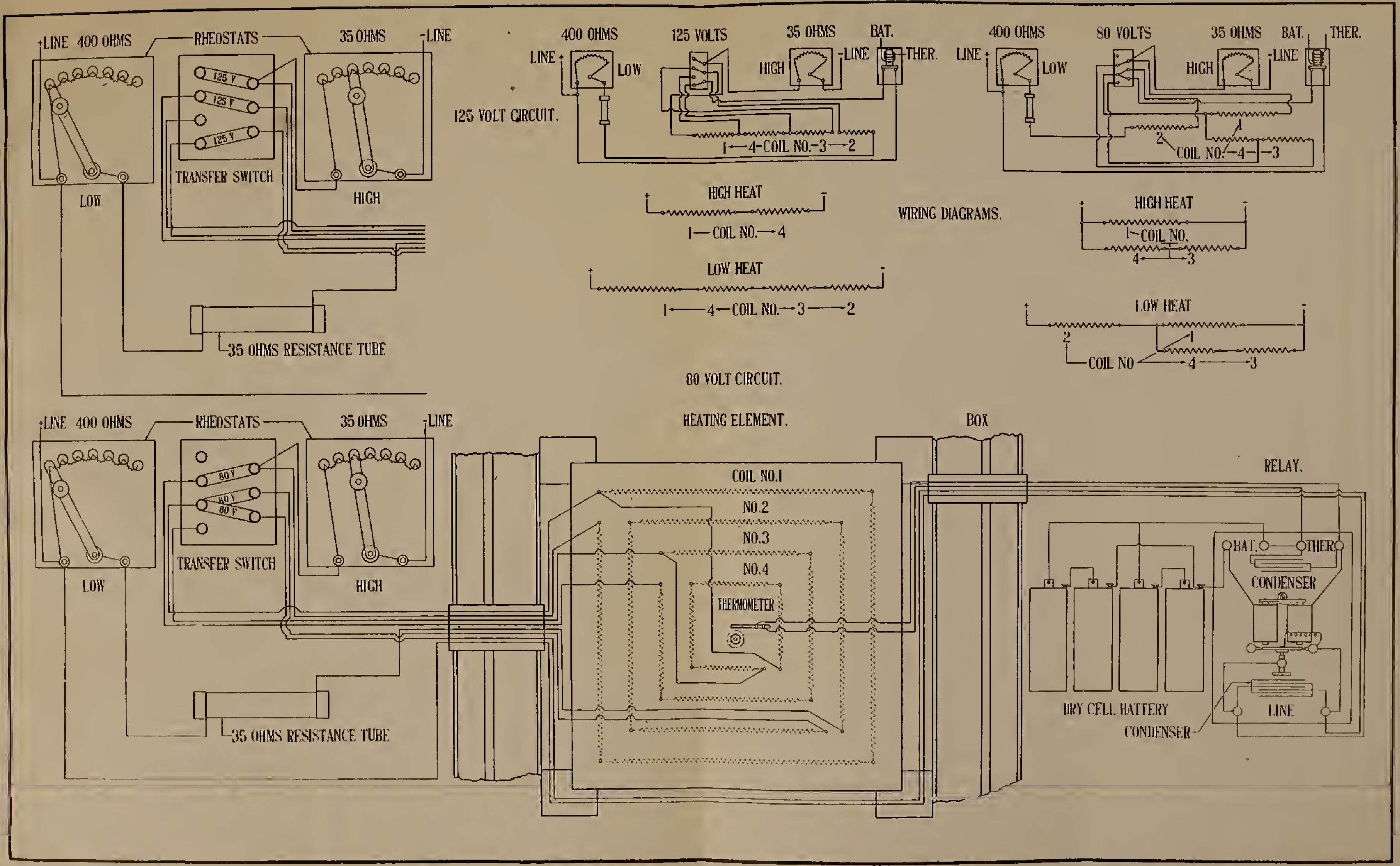
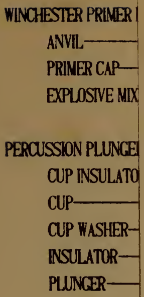
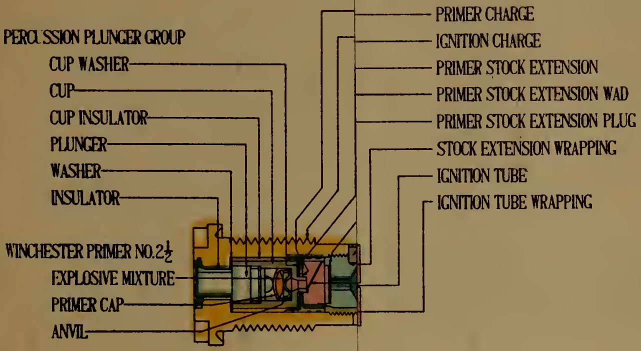
4 3
LOW HEAT
1
COIL NO 4 3
+LINE 400 OHMS
RHEOSTATS
80 V
80 V
80 V
TRANSFER SWITCH
LOW
35 OHMS RES
RELAY.
BAT.
THER.
CONDENSER
CELL BATTERY
LINE
CONDENSER



Surveillance Oven, Mark II, Mod. 2. Wiring Diagram.

PLATE LVI.





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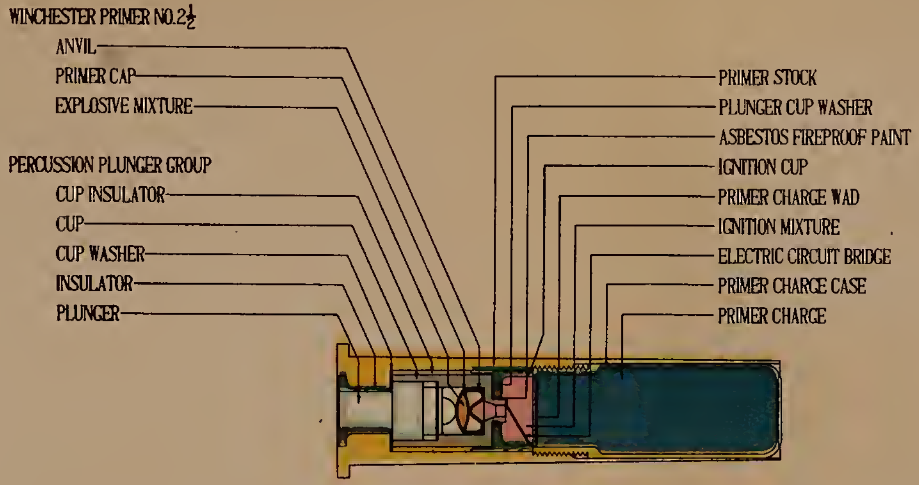

FIG. 1. LOCK COMBINATION PRIMER, MARK XV.

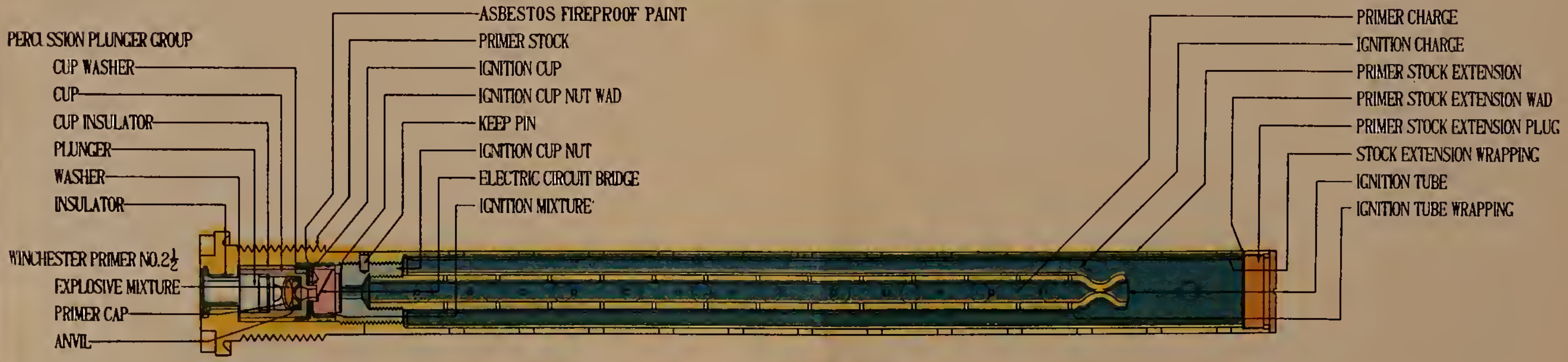

FIG. 2. CASE COMBINATION IGNITION PRIMER, MARK XIII.

Primers, Lock Combination and Case Combination Ignition.

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